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TERRIER Structural Firing Test

Aboard the USS LEAHY (DLG-16)

by

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CONTENTS

ABSTRACT

Ten TERRIER Mk 12 Mod 0 boosters with concrete slugs were fired aboard the USS LEAHY (DLG-16) to investigate the adequacy of protection for the TERRIER launching system personnel against blast effects and to determine the effects of the booster blast on the ship's structure. The test vehicles were fired at various angles such that the exhaust stream was directed at areas thought to impose the most severe conditions on the ship's structural components and equipment. Measurements were made of structural deflections and strains, sound pressure levels, toxic gas concentrations, pressures, flame penetrations at door and port seals, and temperature changes on equipment and in areas manned during missile firings. High-speed motion pictures were taken on all tests.

The results of the tests indicated leakage of gas and smoke into the ship through ventilation systems and past seals of various doors and ports, high temperature changes at the openings of the air escape vents for the JP-5 and the fuel oil tanks; and minor structural damage to equipment in the launcher areas.

FOREWORD

This is the final report of the TERRIER structural firing tests aboard the USS LEAHY (DLG-16) conducted under BUWEPS Task Assignment RM2548-004/210-3/W015B-006 of 28 December 1961 in accordance with reference (a) except for the order of testing. The tests were conducted to determine the effects of the TERRIER booster blast on the ship's structure and to evaluate the adequacy of protection for the TERRIER launching systems personnel against blast effect.

The preliminary results of these tests were reported in reference (b).

This report was reviewed by the following members of the Weapons Development and Evaluation Laboratory:

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INTRODUCTION

Structural firing tests were conducted aboard the USS LEAHY (DLG-16) to establish the adequacy of the ship's structure to withstand the booster blast and to test for safe habitability of areas manned during missile firings. The tests also served to determine the adequacy of the door seals, ports, and equipment exposed to the booster blast. The tests were accomplished by firing ten blast test vehicles (BTV), at various angles of train and elevation such that the exhaust stream was directed at areas believed to impose the most severe conditions on the ship's structural components and equipment. Six BTV's were fired from Launcher No. 1 and four from Launcher No. 2. Each BTV consisted of a Mk 12 Mod 0 booster with a concrete slug. Detailed test objectives are given in the test plan, reference (a) and repeated in Appendix D.

On board the LEAHY were instrumentation teams for measuring toxic gas concentrations, sound pressure levels, structural strains, structural deflections, air temperatures, exhaust stream pressures, and for providing high-speed photographic coverage. The instrumentation was moved for each test to make all measurements in the same configuration with respect to the impingement areas. The detailed results of tests with each launcher are grouped according to type of measurement rather than by test to avoid repeated reference to the kind of measurement considered.

TEST PROCEDURE

The structural firing tests were conducted aboard the USS LEAHY (DLG-16) on 25 and 26 October 1962 in accordance with reference (a) except for the order of firing. For each test a blast test vehicle was launched from either the "A" rail or "B" rail of the Mk 5 Mod 7 (01 level, forward) or the Mk 5 Mod 3 (main deck, aft) guided missile launcher. The launcher angles, impingement areas, and the sequence in which the tests were conducted are outlined in Table 1. The tests were conducted as part of the BUWEPS Qualification Tests for guided missile ships and were fired in the Boston operational area.

At the completion of each firing a description of the damage was recorded and the damaged areas photographed. The test data were returned to Dahlgren for detailed analysis and reporting.

The procedures followed by the different groups in obtaining each kind of measurement or observation for each TERRIER launcher are described in the following paragraphs:

1. Camera Coverage

Camera coverage was arranged to provide information on structural damage, for observing the extent of flame entrance at door and hatch seals, and to document the other test instrumentation on all tests. Details for each camera including its location, type, speed and coverage are included in Table 2.

2. Deflection Measurements

Deflection measurements were made to determine the motion of the TERRIER Strikedown Hatches H-1-47-2 and H-1-47-1 relative to their respective frames. Deflection measurements were also made to determine the displacement of the supporting bulkhead around Door 1-176-2. Details of test equipment and procedure are included in Appendix C.

3. Strain Measurements

Strain measurements were made during the firing of Rounds 7 and 8 to determine the effect of the booster blast on the supporting bulkhead around Door 1-176-2. Details of the test equipment and procedure are included in Appendix C.

4. Sound Pressure Levels

Sound pressure level measurements were made in areas adjacent to the missile launchers to provide information on the high intensity noise levels generated by the firing of the TERRIER boosters. The microphones were located for each test as shown in Figures 1 and 2 and identified by Table 3. Details of test equipment and procedure are included in Appendix C.

5. Toxic Gas Sampling

Shipboard toxicity tests were conducted to determine the presence and the concentration of noxious gas leakage into the interior of the ship. Among the expected products of combustion were carbon monoxide and lead. Details of the test equipment and procedure are included in Appendix C.

6. Temperature Measurements

The air temperature was monitored in operational areas that would be manned during missile launchings to record any change in temperature attributable to the firing of the boosters. Temperature measurements were also recorded in other areas to obtain an approximation of the temperature to which equipment and material would be exposed. The areas in which the temperatures were measured are indicated in Table 4. Details of test equipment and procedure are included in Appendix C.

7. Pressure Measurements

Pressure measurements were made during the firing of Rounds 7, 8 and 10 to determine the loading of the ball check valve in the fuel oil escape vents located at Frame 176, port and starboard. Pressures were also made during Rounds 7 and 8 to determine the forces acting on the sides of the deckhouse and the supporting structure for Door 1-176-2. Details of test equipment and procedure are included in Appendix C.

8. Flame Indicators

Flame indicators were used to provide evidence of flame or hot gas leakage past the seals of doors, hatches, or ports into the interior of the ship. Details of test equipment and procedure are included in Appendix C.

RESULTS AND DISCUSSION

The structural firing tests were successfully conducted on 25 and 26 October 1962. The data collected and the observations made during and after the tests indicated there were no major structural deficiencies. There was smoke and toxic gas leakage into the ship during five of the firings and minor structural damage to equipment mounted on the sides of the missile houses, the main deck, and the 01 level. Detailed discussions of each kind of measurement and of the damage incurred are included in the following paragraphs:

1. Deflection Measurements

The deflection gauge measurements indicated a maximum opening of .001 inch at the forward end and center section, outboard side, of Strikedown Hatch H-1-47-2. The outboard edge of Strikedown Hatch H-1-47-1 showed a maximum opening of .002 inch on the forward end and .006 inch at the center section of the hatch.

Deflection measurements obtained on a vertical stiffener to the supporting bulkhead around Door 1-176-2 indicated maximum deflections of .048, .043 and .029 inch toward the inside of the ship. With reference to Figure 3, these deflections were measured at points 1, 2 and 3 respectively.

2. Strain Measurements

The maximum strains measured on a vertical stiffener to the supporting bulkhead around Door 1-176-2 were 124, 171 and 176 microinches per inch of elongation. With reference to Figure 3, these strains were measured at points 4, 5 and 6 respectively. The elongations measured along the inboard surface of the stiffener indicate a bulkhead motion toward the inside of the ship.

3. Sound Pressure Levels

Sound instrumentation functioned satisfactorily during all firings except Round 8. A power failure resulted in the loss of sound measurements during this round. The maximum level observed was 155 db in the ECM Room No. 1 05-94-0-Q during Round 6.

A spectrum analysis of each noise recording was made using a Bruel and Kjaer spectrum analyzer. The output signals from the magnetic tapes were applied successively to each filter of the 1/3 octave spectrum analyzer and a complete time history for each filter was plotted using a high-speed signal level recorder. The maximum sound pressure level was derived from each time history curve and the results for each test are listed in Tables 5 through 34. The maximum (over-all) sound pressure level for each test was obtained from the time history plot of the Linear "C" Network of Bruel and Kjaer sound equipment. A summary of these measurements is contained in Table 3. All sound pressure level measurements were furnished to the Bureau of Medicine and Surgery for an evaluation of health hazards to operating personnel.

4. Toxic Gas Sampling

The analysis of the air samples collected during the conduct of these tests indicated there was gas leakage into the ship during five of the firings. Smoke was also observed by the test personnel in various compartments during five of the firings. The gas and smoke leakage into the ship was through the ventilation systems and past the seals of various doors and scuttles. Details concerning the kind and number of air samples, areas checked, access and sampling time, and the concentration of gases are included in Table 35. The compartments in which smoke or fumes were observed are also listed in Table 35.

The smoke and high concentration of lead, observed in the Emergency Generator Control Room No. 1 1-20-01-Q and Emergency Generator Room No. 1 1-20-0-E, entered the areas when the edge of Scuttle 01-25-2 was lifted by the booster blast impinging on the coaming of the scuttle.

The smoke observed in both the Battery Room and the Dry Provisions Storeroom 6-207-0-A is believed to have entered the areas through the exhaust ventilation systems terminating in Fan Room 1-178-2-Q on the portside of the main deck. The fan room is not equipped with a water-tight door that can be closed to prohibit the entry of smoke and gases during missile firings.

The smoke observed in Passage 1-174-1-L during Round 10 was attributed to Door 1-176-1 being unlatched by the booster blast. High-speed photographic coverage of the door showed the handle unlatching and the smoke and flame entering around the door. The photographic coverage of Door 1-176-2 on the portside showed that the handle moved but did not completely unlatch during Rounds 7 and 8.

High concentrations of lead were detected in the Crew Living Space 2-20-0-L before and during the firing of Rounds 1 and 5. The lead concentration is attributed to some condition in the ship and not as a result of the booster blast.

Information concerning toxic gases in this report was furnished to the Bureau of Medicine and Surgery for an evaluation of health hazards to operating personnel.

5. Temperature Measurements

Thermocouples located at the openings of the air escape vents for the JP-5 and fuel oil tanks recorded high temperature changes during Rounds 6, 7, 8 and 10. The maximum temperature recorded at the JP-5 air escape vents, located forward of Launcher No. 1, was 1215°F during Round 6. The maximum temperature obtained at the fuel oil vents, located on the port and starboard sides of the main deck at Frame 176, were 2525°F (port) and 2550°F (starboard). Temperature-versus-time curves for the thermocouples at the JP-5 and fuel oil air escape vents are shown in Figures 4 through 8. The location of all the thermocouples and the maximum temperatures recorded are indicated in Table 4.

6. Pressure Measurements

The maximum pressures obtained at the opening of the fuel oil air escape vents, Figure 9, were approximately 6 psig. Pressure-versus-time curves for each of the fuel oil air escape vent locations are shown in Figures 10 through 12. The maximum pressure recorded on the supporting structure for Door 1-176-2 was 17 psig. The location of all the gauges and the maximum pressures recorded are indicated in Table 36.

7. Flame Indicators

The results indicated that gas and flame leakage occurred around Door 1-176-1 during Round 10. There were no indications of flame leakage past the seals of the other structural components listed in Table 37.

8. Structural Damage

The damage incurred during the structural firing tests was superficial and is outlined below:

a. Forward System

(1) The outer glass surface of the missile observation port was melted by the hot gas leakage past the metal cover as seen in Figure 13. The peripheral gaskets for the observation port had not been installed.

(2) The Sound powered phone boxes at Frame 50, port and starboard, were damaged and three sound powered phones were burned.

(3) Instruction plates located on the starboard side of the missile house were burned or completely destroyed, Figure 14.

(4) The rubber gasket on the water-tight Scuttle 01-25-2 was burned and the edge of the scuttle was forced upward by the booster blast causing entry of smoke into the Emergency Generator Control Room No. 1 1-20-01-Q, Figure 15.

(5) The A dud-jettisoning piston for Launcher No. 1 was extended by the blast during Round 5, Figure 16. The unit contained ORDALT 4679 and Northern Ordnance representatives also modified the unit prior to the test by installing a metal band around the periphery of the cap, Figure 16. The purpose of the band was

to prevent leakage of gases into the unit. It was noted by the EP-2 panel operator that the launcher motors did not shut down until after the BTV had cleared the rail. The piston was restowed after the test.

b. Aft System

(1) The wire mesh screens for the four fuel oil air escape vents, located at Frame 176 port and starboard, were burned by the booster exhaust and the ball enclosures distended. At the completion of the firings, all of the air escape vents were disassembled and the check valves inspected for damage. The inspection showed that three of the check valves were distorted where they seat at the top of the vents and that one of the check valves had been ruptured, Figure 17. The damage to the ball check valves was attributed to the high overpressure and the resultant impact load upon seating. There also were indications of smoke leakage past the seals of the vents into the fuel oil vents (AE MN 6-174-0-F & 6-185-0-F) and (AE 6-161-1-F) each time the ship rolled to the starboard after Round 10.

(2) The metal cover for the fire hose rack, Frame 177, starboard, main deck, was blown off and the fire hose scorched, Figure 18.

(3) The life lines on the main deck, portside, Frame 180, were burned.

(4) The sound powered phone storage box, main deck, portside, Frame 177, was blown off the bulkhead.

(5) The spring clips in the gasket seal of the A blast door for Launcher No. 2 were blown loose during Round 9, Figure 19.

(6) A toggle pin at the bottom of the ladder on the main deck, portside, Frame 177, was blown out and the ladder twisted, Figure 20.

(7) Brackets for securing the boat boom vang king post were distorted, Figure 20.

CONCLUSIONS

It is concluded that the damage caused by the blast of the TERRIER Mk 12 Mod 0 booster during the structural firing tests was minor. It appears that relocation of the fuel oil air escape vents, installation of a gas tight door on Fan Room 1-178-2-Q, and relocation of equipment mounted in the blast areas on the main deck and 01 level would eliminate most of the damage and gas leakage during missile firings.

It is further concluded that the missile strikedown hatches can withstand booster blast if properly adjusted and secured.

Conclusions regarding the effect of strains and forces on the ship's structure will be drawn by the Bureau of Ships.

RECOMMENDATIONS

It is recommended that:

1. The peripheral gaskets for the missile observation port be installed in the DLG-17 for evaluation during blast tests in that ship.

2. Scuttle 01-25-2 be replaced with a flush deck type scuttle.

3. The JP-5 vents be grouped together and shielded from the booster blast.

4. The dud-jettisoning units be instrumented during blast tests in the DLG-17 to determine the magnitude of forces acting on the unit as a result of booster blast. The data obtained be used to design a positive latch to prevent extension of the piston during missile firings.

5. The fuel oil air escape vents be relocated clear of the blast area.

6. Sound powered telephone storage boxes be located in an area protected from the booster blast.

7. The fire hose rack located on the main deck, starboard side, Frame 177 be relocated.

8. The ladder on the main deck, portside, be more rigidly secured.

9. The boat boom vang king post be relocated out of the blast area.

10. An investigation be conducted to determine the feasibility of installing a gas tight door on Fan Room 1-178-2-Q to prevent smoke and toxic gases from entering the ship during missile firings.

11. An investigation be conducted to determine the source of lead concentrations detected in the Crew Living Space 2-20-0-L prior to the booster firings.

12. A positive latching device be designed and installed on all compartment doors in the immediate blast area.

REFERENCES

(a) NWL, Dahlgren "Test Plan for TERRIER Structural Firing Tests Aboard the USS LEAHY (DLG-16)" of 1 October 1963
(b) NWL, Dahlgren ltr WDEP:JWL:efl 8800/TE/S of 2 January 1963

APPENDIX A

TABLE 1

LAUNCHER CONDITIONS FOR BLAST TESTS ABOARD USS LEAHY (DLG-16)

Round No.	Test No.	Rail Fired	Train	Elevation	Impingement Area
			Launcher No. 1		
1	1	A	328°	26°	Observer's Port
2	4	A	308°	02°17'	Missile House Face Plate
3	2	A	030°	36°	Port Missile Strikedown Hatch
4	3	B	342°02'	27°	Starboard Missile Strikedown Hatch
5	5	A	147°05'	14°06'	Scuttle 01-25-2
6	6	B	176°	40°28'	A Dud Jettisoning Unit
			Launcher No. 2		
7	1	B	147°08'	11°	Main Deck Portside Frame 178
8	2	B	149°26'	11°	Slanting Bulkhead Portside Frame 182-1/2
9	3	A	165°25'	11°	Observer's Port
10	4	A	212°25'	11°	Main Deck Starboard Frame 178

TABLE 2

CAMERA COVERAGE

Rd. No.		Camera	Location	Speed (Frames/Sec)	Focal Length of Lens	Coverage
1	a.	16mm Benson Lehner	04 Level	400	20mm	Launcher Area
	b.	16mm Benson Lehner	04 Level	400	17mm	Launcher Area
	c.	16mm Vought	Wing and Fin Assembly Area	200	0.7mm	Observation Port
2	a.	16mm Benson Lehner	04 Level	400	20mm	Launcher Area
	b.	16mm Benson Lehner	04 Level	400	17mm	Launcher Area
	c.	16mm Vought	Wing and Fin Assembly Area	200	10mm	Starboard Blast Door
3	a.	16mm Benson Lehner	04 Level	400	20mm	Launcher Area
	b.	16mm Benson Lehner	04 Level	400	17mm	Launcher Area
	c.	16mm Vought	Wing and Fin Assembly Area	200	10mm	Port Strikedown Hatch
4	a.	16mm Benson Lehner	04 Level	400	20mm	Launcher Area
	b.	16mm Benson Lehner	04 Level	400	17mm	Launcher Area
	c.	16mm Vought	Wing and Fin Assembly Area	200	10mm	Starboard Strikedown Hatch

TABLE 2 (Continued)

Rd. No.		Camera	Location	Speed (Frames/Sec)	Focal Length of Lens	Coverage
5	a.	16mm Benson Lehner	04 Level	400	20mm	Launcher Area
	b.	16mm Benson Lehner	04 Level	400	85mm	Launcher Area
6	a.	16mm Benson Lehner	04 Level	400	20mm	Launcher Area
	b.	16mm Benson Lehner	04 Level	400	85mm	A Dud Jettisoning Unit
7	a.	16mm Benson Lehner	02 Level	400	17mm	Launcher Area
	b.	16mm Vought	Passage 1-174-2-L	200	10mm	Portside Door D-1-176-2
8	a.	16mm Benson Lehner	02 Level	400	17mm	Launcher Area
	b.	16mm Vought	Passage 1-174-2-L	200	10mm	Portside Door D-1-176-2
9	a.	16mm Benson Lehner	02 Level	400	17mm	Launcher Area
	b.	16mm Vought	Wing and Fin Assembly Area	200	10mm	Starboard Blast Door and Observation Port
10	a.	16mm Benson Lehner	02 Level	400	17mm	Launcher Area
	b.	16mm Vought	Passage 1-174-1-L	200	10mm	Starboard Door D-1-176-1

TABLE 3 SUMMARY OF NOISE LEVEL MEASUREMENTS

Rd. No.	Location	No. in Figure 1	Ambient SPL(1) (db)	Maximum SPL(2) (db)	Duration of Booster Noise(3) (sec.)	Base Line (db)
1	Observer's Port Station	1	84	140	0.71	120
	Missile Safety Observer Station 1-17-1-C	2	80	134	0.96	115
2	Observer's Port Station	1	84	117	0.66	110
	Missile Safety Observer Station 1-17-1-C	2	80	126	1.60	110
3	Missile Checkout Area 1-35-01-M	3	85	114	0.58	110
	Missile Assembly and Loading Area 1-47-0-M	4	83	126	1.16	110
	CPO Messroom and Lounge 1-61-2-L	5	83	*	-	-
	Passage 1-47-2-L	4	84	130	1.23	115
	Passage 1-61-4-L	5	86	127	0.73	115
4	Missile Checkout Area 1-35-01-M	3	85	124	0.83	110
	Missile Assembly and Loading Area 1-47-0-M	4	83	125	1.06	110
	CPO Messroom and Lounge 1-61-2-L	5	83	*	-	-

TABLE 3 (Continued)

Rd. No.	Location	No. in Figure 1	Ambient SPL(1) (db)	Maximum SPL(2) (db)	Duration of Booster Noise(3) (sec.)	Base Line (db)
4	Passage 1-35-3-L	3	88	132	1.18	110
	Passage 1-47-1-L	4	88	126	0.46	120
	Passage 1-61-3-L	5	92	118	0.95	110
5	Barber Shop 1-29-2-Q	6	82	126	0.70	110
	Emergency Generator Control Room No. 1 1-20-01-Q	7	78	133	1.15	110
	Passage 1-32-2-L	3	84	135	1.20	110
6	ASROC Launcher Control Station 02-68-0-C	8	82	120	0.86	105
	Pilot House 03-68-0-C	9	79	130	1.13	110
	04 Level at Frame 70	10	82	148	1.53	110
	ECM Room No. 1 05-94-0-Q	11	82	155	1.43	125
7	Steering Gear Room 2-211-0-E	12**	94	131	1.56	110
	Emergency Generator Room No. 2 2-203-0-E	13**	86	136	1.30	110
	Laundry 2-194-0-Q	14**	88	120	0.75	105

**Figure 2

TABLE 3 (Continued)

Rd. No.	Location	No. in Figure 2	Ambient SPL(1) (db)	Maximum SPL(2) (db)	Duration of Booster Noise(3) (sec.)	Base Line (db)
7	Crew's Living Space 2-185-01-L	15	88	129	1.13	110
	Crew's Living Space 2-174-0-L	16	82	128	1.16	115
8	No data					
9	Missile Checkout Area 1-174-0-M	17	80	121	0.61	110
	Missile Assembly and Loading Area 1-161-0-M	18	86	120	0.76	110
	Crew's Living Space 1-152-0-L	19	80	*	-	-
	Auxiliary Radio Room 01-152-0-M	19	85	*	-	-
	3"/50 Ready Service Room 01-152-0-M	20	82	117	0.60	115
10	Passage 1-174-1-L	18	78	140	1.23	115
	Missile Safety Observer Station 2-215-2-C	21	92	132	1.23	110

*Less than 100 db.

(1)Sound Pressure Level Re 0.0002 dynes/cm^2 (Ambient SPL measured with sound level meter).

(2)Over-all value obtained from Linear "C" Network of the spectrum analyser.

(3)Time from first indication of booster noise until decay of booster noise to a level designated on "Base Line".

TABLE 4 AIR TEMPERATURE MEASUREMENTS

Rd. No.	Location	Temperature Before Firing (°F)	Maximum Temperature (°F)	Temperature Rise (°F)
1	FAST Equipment, Frame 43	44	58	14
	Outboard Cell, ASROC Launcher, Port	44	148	104
	Outboard Cell, ASROC Launcher, Starboard	44	148	104
2	FAST Equipment, Frame 43	48	341	293
	Outboard Cell, ASROC Launcher, Port	48	233	185
	Outboard Cell, ASROC Launcher, Starboard	48	221	173
3	FAST Equipment, Frame 43	49	2343	2294
4	ASROC Loader Crane Controls	49	274	225
5	JP-5 Air Escape Vent, Frame 19	50	202	152
	JP-5 Air Escape Vent, Frame 23	50	200	150
6	JP-5 Air Escape Vent, Frame 19	50	1215	1165
	JP-5 Air Escape Vent, Frame 23	50	845	795
7	Fuel Oil Vent (AE MN 6-174-0-F)	50	1695	1645
	Fuel Oil Vent (AE MN 6-185-0-F)	50	2525	2475
	Passage 1-174-2-L	72	72	0

TABLE 4 (Continued)

Rd. No.	Location	Temperature Before Firing (°F)	Maximum Temperature (°F)	Temperature Rise (°F)
8	Fuel Oil Vent (AE MN 6-174-0-F)	50	2130	2080
	Fuel Oil Vent (AE MN 6-185-0-F)	50	2315	2265
	Passage 1-174-2-L	72	72	0
	*Vertical Stiffener Door D-1-176-2	50	278	228
	*Vertical Stiffener Door D-1-176-2	50	180	130
	*Bulkhead, Frame 177, 36 inches above Main Deck	50	227	177
10	Fuel Oil Vent (AE MN 6-174-0-F)	50	2270	2220
	Fuel Oil Vent (AE MN 6-161-1-F)	50	2550	2500
	Passage 1-174-1-L	72	72	0

*Gauge Location shown in Figure 3.

TABLE 5 ROUND NO. 1

SPECTRUM ANALYSIS OF NOISE AT OBSERVER'S PORT STATION

Center Frequency of 1/3 Octave Band Pass Filter (cps)	Maximum Sound Pressure Level (db) Re 0.0002 dynes/cm^2
40	104
50	103
63	109
80	114
100	115
125	131
160	131
200	129
250	127
315	127
400	128
500	130
630	124
800	124
1000	127
1250	128
1600	131
2000	131
2500	131
3150	131
4000	129
5000	124
6300	122
8000	118
10000	118

TABLE 6 ROUND NO. 1

SPECTRUM ANALYSIS OF NOISE AT
MISSILE SAFETY OBSERVER STATION 1-17-1-C

Center Frequency of 1/3 Octave Band Pass Filter (cps)	Maximum Sound Pressure Level (db) Re 0.0002 dynes/cm^2
40	104
50	105
63	106
80	113
100	118
125	126
160	127
200	121
250	124
315	115
400	117
500	124
630	123
800	117
1000	114
1250	114
1600	120
2000	115
2500	112
3150	112
4000	113
5000	114
6300	112
8000	105
10000	103

TABLE 7 ROUND NO. 2

SPECTRUM ANALYSIS OF NOISE AT OBSERVER'S PORT STATION

Center Frequency of 1/3 Octave Band Pass Filter (cps)	Maximum Sound Pressure Level (db) Re 0.0002 dynes/cm^2
40	< 100
50	< 100
63	102
80	109
100	107
125	106
160	106
200	103
250	< 100
315	101
400	101
500	100
630	101
800	102
1000	103
1250	103
1600	102
2000	102
2500	101
3150	101
4000	100
5000	< 100
6300	< 100
8000	< 100
10000	< 100

TABLE 8 ROUND NO. 2

SPECTRUM ANALYSIS OF NOISE AT
MISSILE SAFETY OBSERVER STATION 1-17-1-C

Center Frequency of 1/3 Octave Band Pass Filter (cps)	Maximum Sound Pressure Level (db) Re 0.0002 dynes/cm^2
40	< 100
50	106
63	117
80	118
100	117
125	113
160	113
200	107
250	110
315	112
400	112
500	113
630	107
800	107
1000	106
1250	109
1600	102
2000	102
2500	104
3150	106
4000	106
5000	100
6300	< 100
8000	< 100
10000	< 100

TABLE 9

ROUND NO. 3

SPECTRUM ANALYSIS OF NOISE AT
MISSILE CHECKOUT AREA 1-35-01-M

Center Frequency of 1/3 Octave Band Pass Filter (cps)	Maximum Sound Pressure Level (db) Re 0.0002 dynes/cm^2
40	< 100
50	100
63	103
80	107
100	105
125	107
160	106
200	100
250	102
315	100
400	100
500	101
630	< 100
800	101
1000	100
1250	100
1600	102
2000	102
2500	102
3150	101
4000	< 100
5000	< 100
6300	< 100
8000	< 100
10000	< 100

TABLE 10 ROUND NO. 3

SPECTRUM ANALYSIS OF NOISE AT
MISSILE ASSEMBLY AND LOADING AREA 1-47-0-M

Center Frequency of 1/3 Octave Band Pass Filter (cps)	Maximum Sound Pressure Level (db) Re 0.0002 dynes/cm^2
40	< 100
50	105
63	111
80	113
100	118
125	116
160	112
200	114
250	113
315	111
400	110
500	110
630	109
800	111
1000	114
1250	114
1600	114
2000	114
2500	114
3150	113
4000	112
5000	108
6300	105
8000	< 100
10000	101

TABLE 11 ROUND NO. 3

SPECTRUM ANALYSIS OF NOISE AT PASSAGE 1-47-2-L

Center Frequency of 1/3 Octave Band Pass Filter (cps)	Maximum Sound Pressure Level (db) Re 0.0002 dynes/cm^2
40	107
50	109
63	111
80	116
100	120
125	123
160	117
200	112
250	111
315	112
400	111
500	107
630	110
800	112
1000	111
1250	111
1600	110
2000	111
2500	107
3150	106
4000	108
5000	103
6300	104
8000	102
10000	111

TABLE 12 ROUND NO. 3

SPECTRUM ANALYSIS OF NOISE AT PASSAGE 1-61-4-L

Center Frequency of 1/3 Octave Band Pass Filter (cps)	Maximum Sound Pressure Level (db) Re 0.0002 dynes/cm^2
40	106
50	106
63	112
80	116
100	118
125	123
160	115
200	109
250	110
315	107
400	108
500	104
630	103
800	105
1000	105
1250	106
1600	104
2000	102
2500	101
3150	< 100
4000	100
5000	< 100
6300	< 100
8000	< 100
10000	< 100

TABLE 13 ROUND NO. 4

SPECTRUM ANALYSIS OF NOISE AT
MISSILE CHECKOUT AREA 1-35-01-M

Center Frequency of 1/3 Octave Band Pass Filter (cps)	Maximum Sound Pressure Level (db) Re 0.0002 dynes/cm^2
40	< 100
50	< 100
63	104
80	119
100	120
125	115
160	116
200	108
250	106
315	107
400	107
500	106
630	107
800	108
1000	106
1250	108
1600	109
2000	109
2500	107
3150	107
4000	105
5000	102
6300	100
8000	< 100
10000	< 100

TABLE 14 ROUND NO. 4

SPECTRUM ANALYSIS OF NOISE AT
MISSILE ASSEMBLY AND LOADING AREA 1-47-0-M

Center Frequency of 1/3 Octave Band Pass Filter (cps)	Maximum Sound Pressure Level (db) Re 0.0002 dynes/cm^2
40	100
50	105
63	113
80	116
100	113
125	114
160	112
200	112
250	114
315	110
400	109
500	111
630	111
800	110
1000	112
1250	113
1600	116
2000	114
2500	113
3150	113
4000	112
5000	107
6300	105
8000	< 100
10000	101

TABLE 15 ROUND NO. 4

SPECTRUM ANALYSIS OF NOISE AT PASSAGE 1-35-3-L

Center Frequency of 1/3 Octave Band Pass Filter (cps)	Maximum Sound Pressure Level (db) Re 0.0002 dynes/cm^2
40	103
50	108
63	117
80	117
100	123
125	122
160	124
200	123
250	117
315	115
400	116
500	111
630	118
800	119
1000	118
1250	119
1600	117
2000	116
2500	110
3150	108
4000	107
5000	101
6300	< 100
8000	< 100
10000	101

TABLE 16 ROUND NO. 4

SPECTRUM ANALYSIS OF NOISE AT PASSAGE 1-47-1-L

Center Frequency of 1/3 Octave Band Pass Filter (cps)	Maximum Sound Pressure Level (db) Re 0.0002 dynes/cm^2
40	< 100
50	105
63	108
80	114
100	113
125	119
160	115
200	113
250	112
315	110
400	108
500	109
630	107
800	109
1000	110
1250	107
1600	110
2000	106
2500	105
3150	103
4000	107
5000	102
6300	102
8000	103
10000	113

TABLE 17 ROUND NO. 4

SPECTRUM ANALYSIS OF NOISE AT PASSAGE 1-61-3-L

Center Frequency of 1/3 Octave Band Pass Filter (cps)	Maximum Sound Pressure Level (db) Re 0.0002 dynes/cm^2
40	100
50	104
63	103
80	105
100	105
125	109
160	107
200	107
250	106
315	105
400	100
500	< 100
630	101
800	< 100
1000	< 100
1250	< 100
1600	100
2000	< 100
2500	< 100
3150	< 100
4000	< 100
5000	< 100
6300	< 100
8000	< 100
10000	< 100

TABLE 18 ROUND NO. 5

SPECTRUM ANALYSIS OF NOISE AT BARBAR SHOP 1-29-2-Q

Center Frequency of 1/3 Octave Band Pass Filter (cps)	Maximum Sound Pressure Level (db) Re 0.0002 dynes/cm^2
40	103
50	105
63	113
80	112
100	118
125	124
160	112
200	110
250	113
315	111
400	109
500	108
630	109
800	111
1000	111
1250	111
1600	109
2000	112
2500	113
3150	114
4000	110
5000	106
6300	104
8000	< 100
10000	< 100

TABLE 19 ROUND NO. 5

SPECTRUM ANALYSIS OF NOISE AT
EMERGENCY GENERATOR CONTROL ROOM NO. 1 1-20-01-Q

Center Frequency of 1/3 Octave Band Pass Filter (cps)	Maximum Sound Pressure Level (db) Re 0.0002 dynes/cm^2
40	115
50	119
63	121
80	117
100	110
125	116
160	121
200	115
250	110
315	112
400	108
500	108
630	111
800	114
1000	115
1250	115
1600	117
2000	120
2500	118
3150	118
4000	118
5000	114
6300	111
8000	105
10000	108

TABLE 20 ROUND NO. 5

SPECTRUM ANALYSIS OF NOISE AT PASSAGE 1-32-2-L

Center Frequency of 1/3 Octave Band Pass Filter (cps)	Maximum Sound Pressure Level (db) Re 0.0002 dynes/cm^2
40	104
50	108
63	112
80	113
100	119
125	131
160	128
200	122
250	113
315	115
400	119
500	116
630	117
800	118
1000	120
1250	120
1600	118
2000	119
2500	116
3150	115
4000	113
5000	110
6300	106
8000	100
10000	101

TABLE 21 ROUND NO. 6

SPECTRUM ANALYSIS OF NOISE AT
ASROC LAUNCHER CONTROL STATION 02-68-0-C

Center Frequency of 1/3 Octave Band Pass Filter (cps)	Maximum Sound Pressure Level (db) Re 0.0002 dynes/cm^2
40	100
50	105
63	101
80	114
100	111
125	104
160	109
200	< 100
250	103
315	100
400	100
500	< 100
630	104
800	100
1000	101
1250	102
1600	102
2000	101
2500	< 100
3150	< 100
4000	< 100
5000	< 100
6300	< 100
8000	< 100
10000	< 100

TABLE 22 ROUND NO. 6

SPECTRUM ANALYSIS OF NOISE AT PILOT HOUSE 03-68-0-C

Center Frequency of 1/3 Octave Band Pass Filter (cps)	Maximum Sound Pressure Level (db) Re 0.0002 dynes/cm^2
40	114
50	117
63	117
80	120
100	120
125	124
160	116
200	114
250	115
315	108
400	107
500	104
630	109
800	105
1000	106
1250	104
1600	104
2000	104
2500	101
3150	< 100
4000	< 100
5000	< 100
6300	< 100
8000	< 100
10000	< 100

TABLE 23 ROUND NO. 6

SPECTRUM ANALYSIS OF NOISE AT 04 LEVEL, FRAME 70

Center Frequency of 1/3 Octave Band Pass Filter (cps)	Maximum Sound Pressure Level (db) Re 0.0002 dynes/cm^2
40	126
50	130
63	127
80	128
100	130
125	140
160	139
200	137
250	139
315	141
400	137
500	136
630	137
800	138
1000	139
1250	140
1600	138
2000	138
2500	138
3150	138
4000	137
5000	134
6300	132
8000	126
10000	131

TABLE 24 ROUND NO. 6

SPECTRUM ANALYSIS OF NOISE AT
ECM ROOM NO. 1 05-94-0-Q

Center Frequency of 1/3 Octave Band Pass Filter (cps)	Maximum Sound Pressure Level (db) Re 0.0002 dynes/cm^2
40	128
50	130
63	134
80	131
100	139
125	137
160	137
200	127
250	135
315	139
400	141
500	140
630	144
800	143
1000	140
1250	143
1600	141
2000	143
2500	143
3150	140
4000	138
5000	136
6300	133
8000	128
10000	132

TABLE 25 ROUND NO. 7

SPECTRUM ANALYSIS OF NOISE AT
STEERING GEAR ROOM 2-211-0-E

Center Frequency of 1/3 Octave Band Pass Filter (cps)	Maximum Sound Pressure Level (db) Re 0.0002 dynes/cm^2
40	115
50	108
63	108
80	114
100	122
125	123
160	114
200	108
250	108
315	104
400	101
500	102
630	105
800	106
1000	106
1250	106
1600	108
2000	110
2500	108
3150	107
4000	106
5000	103
6300	< 100
8000	< 100
10000	< 100

TABLE 26 ROUND NO. 7

SPECTRUM ANALYSIS OF NOISE AT
EMERGENCY GENERATOR ROOM NO. 2 2-203-0-E

Center Frequency of 1/3 Octave Band Pass Filter (cps)	Maximum Sound Pressure Level (db) Re 0.0002 dynes/cm^2
40	122
50	122
63	122
80	121
100	122
125	124
160	123
200	123
250	121
315	118
400	121
500	118
630	118
800	121
1000	121
1250	120
1600	120
2000	118
2500	119
3150	115
4000	112
5000	108
6300	108
8000	104
10000	105

TABLE 27 ROUND NO. 7

SPECTRUM ANALYSIS OF NOISE AT LAUNDRY 2-194-0-Q

Center Frequency of 1/3 Octave Band Pass Filter (cps)	Maximum Sound Pressure Level (db) Re 0.0002 dynes/cm^2
40	100
50	110
63	107
80	105
100	111
125	115
160	113
200	104
250	104
315	103
400	102
500	101
630	< 100
800	< 100
1000	< 100
1250	101
1600	102
2000	< 100
2500	< 100
3150	< 100
4000	< 100
5000	< 100
6300	< 100
8000	< 100
10000	< 100

TABLE 28

ROUND NO. 7

SPECTRUM ANALYSIS OF NOISE AT
CREW'S LIVING SPACE 2-185-01-L

Center Frequency of 1/3 Octave Band Pass Filter (cps)	Maximum Sound Pressure Level (db) Re 0.0002 dynes/cm^2
40	106
50	115
63	121
80	118
100	116
125	115
160	118
200	118
250	115
315	112
400	114
500	111
630	115
800	114
1000	115
1250	115
1600	115
2000	114
2500	113
3150	112
4000	108
5000	105
6300	101
8000	< 100
10000	< 100

TABLE 29 ROUND NO. 7

SPECTRUM ANALYSIS OF NOISE AT
CREW'S LIVING SPACE 2-174-0-L

Center Frequency of 1/3 Octave Band Pass Filter (cps)	Maximum Sound Pressure Level (db) Re 0.0002 dynes/cm^2
40	107
50	108
63	105
80	115
100	112
125	112
160	117
200	115
250	109
315	109
400	109
500	108
630	111
800	112
1000	111
1250	114
1600	112
2000	112
2500	110
3150	110
4000	110
5000	106
6300	106
8000	< 100
10000	109

TABLE 30 ROUND NO. 9

SPECTRUM ANALYSIS OF NOISE AT
MISSILE CHECKOUT AREA 1-174-0-M

Center Frequency of 1/3 Octave Band Pass Filter (cps)	Maximum Sound Pressure Level (db) Re 0.0002 dynes/cm^2
40	< 100
50	< 100
63	100
80	< 100
100	< 100
125	111
160	115
200	107
250	107
315	107
400	108
500	105
630	104
800	108
1000	108
1250	110
1600	113
2000	113
2500	110
3150	107
4000	107
5000	103
6300	101
8000	< 100
10000	< 100

TABLE 31 ROUND NO. 9

SPECTRUM ANALYSIS OF NOISE AT
MISSILE ASSEMBLY AND LOADING AREA 1-161-0-M

Center Frequency of 1/3 Octave Band Pass Filter (cps)	Maximum Sound Pressure Level (db) Re 0.0002 dynes/cm^2
40	< 100
50	100
63	109
80	112
100	112
125	113
160	109
200	108
250	102
315	102
400	101
500	100
630	101
800	103
1000	106
1250	105
1600	106
2000	107
2500	105
3150	104
4000	104
5000	< 100
6300	< 100
8000	< 100
10000	< 100

TABLE 32 ROUND NO. 9

SPECTRUM ANALYSIS OF NOISE AT
3"/50 READY SERVICE ROOM 01-152-0-M

Center Frequency of 1/3 Octave Band Pass Filter (cps)	Maximum Sound Pressure Level (db) Re 0.0002 dynes/cm^2
40	< 100
50	< 100
63	< 100
80	< 100
100	< 100
125	104
160	104
200	104
250	103
315	103
400	105
500	106
630	101
800	105
1000	102
1250	103
1600	104
2000	103
2500	102
3150	102
4000	107
5000	102
6300	102
8000	< 100
10000	< 100

TABLE 33 ROUND NO. 10

SPECTRUM ANALYSIS OF NOISE AT PASSAGE 1-174-1-L

Center Frequency of 1/3 Octave Band Pass Filter (cps)	Maximum Sound Pressure Level (db) Re 0.0002 dynes/cm^2
40	128
50	130
63	130
80	133
100	133
125	134
160	130
200	126
250	127
315	122
400	126
500	126
630	127
800	124
1000	127
1250	128
1600	128
2000	126
2500	124
3150	122
4000	119
5000	117
6300	115
8000	110
10000	110

TABLE 34 ROUND NO. 10

SPECTRUM ANALYSIS OF NOISE AT
MISSILE SAFETY OBSERVER STATION 2-215-2-C

Center Frequency of 1/3 Octave Band Pass Filter (cps)	Maximum Sound Pressure Level (db) Re 0.0002 dynes/cm^2
40	110
50	111
63	110
80	117
100	119
125	121
160	123
200	119
250	118
315	112
400	112
500	112
630	110
800	109
1000	113
1250	114
1600	117
2000	115
2500	111
3150	108
4000	106
5000	101
6300	100
8000	< 100
10000	100

TABLE 35

RESULTS OF GAS TESTS AND SMOKE OBSERVATION

Round No.	Type of Sample	No. of Samples	Sampling Area	Access or Sampling Time	Concentration	Remarks
1	Carbon Monoxide	2	Observer Port Station.	X to X+2.5 Min.	Less than 10 ppm	
		1	Missile Checkout Area 1-35-01-M.	X to X+2.5 Min.	Less than 10 ppm	
		1	Missile Assembly and Loading Area 1-47-0-M.	X to X+2.5 Min.	Less than 10 ppm	
		1	Crew's Living Space 2-20-0-L.	X to X+2.5 Min.	Less than 10 ppm	
		1	Crew's Living Space 2-35-0-L.	X to X+2.5 Min.	Less than 10 ppm	
	*Lead	1	Observer Port Station.	X to X+5 Min.	.000 Mg/m^3	
		1	Missile Checkout Area 1-35-01-M.	X to X+5 Min.	.000 Mg/m^3	
		1	Crew's Living Space 2-35-0-L.	X to X+5 Min.	.000 Mg/m^3	
		1	Crew's Living Space 2-20-0-L.	X to X+5 Min.	.110 Mg/m^3	Lead concentration high regardless of ambient sample or firing sample.
		1	Missile Assembly and Loading Area 1-47-0-M.	X to X+5 Min.	.000 Mg/m^3	
	**Lead	1	Observer Port Station.	X to X+2.5 Min.	.000 Mg/m^3	
		1	Missile Checkout Area 1-35-01-M.	X to X+2.5 Min.	.000 Mg/m^3	
2	Carbon Monoxide	2	Observer Port Station.	X to X+2.5 Min.	Less than 10 ppm	
		2	Missile Checkout Area 1-35-01-M.	X to X+2.5 Min.	Less than 10 ppm	
		1	Missile Assembly and Loading Area 1-47-0-M.	X to X+2.5 Min.	Less than 10 ppm	
	*Lead	1	Observer Port Station.	X to X+5 Min.	.000 Mg/m^3	
		1	Missile Checkout Area 1-35-01-M.	X to X+5 Min.	.000 Mg/m^3	
		1	Missile Assembly and Loading Area 1-47-0-M.	X to X+5 Min.	.000 Mg/m^3	
	**Lead	1	Observer Port Station.	X to X+2.5 Min.	.000 Mg/m^3	
		1	Missile Checkout Area 1-35-01-M.	X to X+2.5 Min.	.000 Mg/m^3	

TABLE 35 (Continued)

Round No.	Type of Sample	No. of Samples	Sampling Area	Access or Sampling Time	Concentration	Remarks
3	Carbon Monoxide	2	Observer Port Station.	X to X+2.5 Min.	Less than 10 ppm	
		1	Missile Checkout Area 1-35-01-M.	X to X+2.5 Min.	Less than 10 ppm	
		2	Missile Assembly and Loading Area 1-47-0-M.	X to X+2.5 Min.	Less than 10 ppm	
		2	Crew's Living Space 2-35-0-L.	X to X+2.5 Min.	Less than 10 ppm	
	*Lead	1	Observer Port Station.	X to X+5 Min.	.000 Mg/m^3	
		1	Missile Checkout Area 1-35-01-M.	X to X+5 Min.	.000 Mg/m^3	
		1	Missile Assembly and Loading Area 1-47-0-M.	X to X+5 Min.	.000 Mg/m^3	
		1	Crew's Living Space 2-35-0-L.	X to X+5 Min.	.000 Mg/m^3	
4	Carbon Monoxide	2	Observer Port Station.	X to X+2.5 Min.	Less than 10 ppm	
		2	Missile Checkout Area 1-35-01-M.	X to X+2.5 Min.	Less than 10 ppm	
		2	Missile Assembly and Loading Area 1-47-0-M.	X to X+2.5 Min.	Less than 10 ppm	
	*Lead	1	Observer Port Station	X to X+5 Min.	.000 Mg/m^3	
		1	Missile Checkout Area 1-35-01-M.	X to X+5 Min.	.000 Mg/m^3	
		1	Missile Assembly and Loading Area 1-47-0-M.	X to X+5 Min.	.000 Mg/m^3	
	**Lead	1	Observer Port Station.	X to X+2.5 Min.	.000 Mg/m^3	
		1	Missile Checkout Area 1-35-01-M.	X to X+2.5 Min.	.000 Mg/m^3	
5	Carbon Monoxide	2	Emergency Generator Room No. 1 1-20-0-E.	X to X+2.5 Min.	Less than 10 ppm	
		1	Emergency Generator Control Room No. 1 1-20-01-Q.	X to X+2.5 Min.	Less than 10 ppm	
		2	Missile Safety Observer Station 1-17-1-C.	X to X+2.5 Min.	Less than 10 ppm	

TABLE 35 (Continued)

Round No.	Type of Sample	No. of Samples	Sampling Area	Access or Sampling Time	Concentration	Remarks
5	Carbon Monoxide	2	Crew's Living Space 2-20-0-L.	X to X+2.5 Min.	Less than 10 ppm	
	*Lead	1	Emergency Generator Room No. 1 1-20-0-E.	X to X+5 Min.	.043 Mg/m^3	Smoke in area, entry through door in Emergency Generator Control Room.
		1	Emergency Generator Control Room No. 1 1-20-01-Q.	X to X+5 Min.	2.820 Mg/m^3	Smoke in area, persisted for 2 minutes, entry through Scuttle 01-25-2.
		1	Missile Safety Observer Station 1-17-1-C.	X to X+5 Min.	.057 Mg/m^3	
		1	Crew's Living Space 2-20-0-L.	X to X+5 Min.	6.250 Mg/m^3	Lead concentration high regardless of ambient sample or firing sample.
	**Lead	1	Emergency Generator Room No. 1 1-20-0-E.	X to X+2.5 Min.	3.958 Mg/m^3	
	Observation		Plenum Chamber 1-22-2-Q.			Smoke in area, entry through ventilation system.
6	Carbon Monoxide	1	Emergency Generator Room No. 1 1-20-0-E.	X to X+2.5 Min.	Less than 10 ppm	
		1	Emergency Generator Control Room No. 1 1-20-01-Q.	X to X+2.5 Min.	Less than 10 ppm	
	*Lead	1	Emergency Generator Room No. 1 1-20-0-E.	X to X+5 Min.	2.561 Mg/m^3	Smoke in area, persisted for approximately 2 minutes, entry through door in Emergency Generator Control Room.
		1	Emergency Generator Control Room No. 1 1-20-01-Q.	X to X+5 Min.	3.196 Mg/m^3	Smoke in area, persisted for approximately 2 minutes, entry through Scuttle 01-25-2.
7	Carbon Monoxide	1	Emergency Generator Control Room No. 2 2-203-2-Q.	X to X+2.5 Min.	Less than 10 ppm	
		1	Missile Checkout Area 1-174-0-M.	X to X+2.5 Min.	Less than 10 ppm	
		1	Passage 1-174-2-L.	X to X+2.5 Min.	Less than 10 ppm	

TABLE 35 (Continued)

Round No.	Type of Sample	No. of Samples	Sampling Area	Access or Sampling Time	Concentration	Remarks
7	Carbon Monoxide	1	3"/50 Gun Mount No. 32.	X to X+2.5 Min.	Less than 10 ppm	
	*Lead	1	Missile Checkout Area 1-174-0-M.	X to X+5 Min.	.000 Mg/m^3	
		1	Passage 1-174-2-L.	X to X+5 Min.	.154 Mg/m^3	Entry thru Door 1-176-2
		1	Crew Decontamination Station 2-174-2-L.	X to X+5 Min.	.000 Mg/m^3	
		1	3"/50 Gun Mount No. 32.	X to X+5 Min.	1.230 Mg/m^3	
	**Lead	1	Emergency Generator Control Room No. 2 2-203-2-Q.	X to X+2.5 Min.	.033 Mg/m^3	
		1	Passage 1-174-2-L.	X to X+2.5 Min.	.072 Mg/m^3	
		1	Missile Checkout Area 1-174-0-M.	X to X+2.5 Min.	.000 Mg/m^3	
8	Carbon Monoxide	2	Missile Checkout Area 1-174-0-M.	X to X+2.5 Min.	Less than 10 ppm	
		2	Passage 1-174-2-L.	X to X+2.5 Min.	Less than 10 ppm	
		2	Steering Gear Room 2-211-0-E.	X to X+2.5 Min.	Less than 10 ppm	
		1	Laundry 2-194-0-Q.	X to X+2.5 Min.	Less than 10 ppm	
		1	3"/50 Gun Mount No. 32	X to X+2.5 Min.	Less than 10 ppm	
	*Lead	1	Missile Checkout Area 1-174-0-M.	X to X+5 Min.	.000 Mg/m^3	
		1	Steering Gear Room 2-211-0-E.	X to X+5 Min.	.000 Mg/m^3	
	**Lead	1	Missile Checkout Area 1-174-0-M.	X to X+2.5 Min.	.000 Mg/m^3	
		1	Steering Gear Room 2-211-0-E.	X to X+2.5 Min.	.000 Mg/m^3	
		1	Passage 1-174-2-L.	X to X+2.5 Min.	In excess of 2.000 Mg/m^3	Lead concentration too high for calibration standard set up for this round. Entry thru Door 1-176-2.
	Observation		Battery Room, starboard side, adjacent to Emergency Generator Control Room No. 2 2-203-2-Q.			Smoke in area, entry through ventilation system, persisted for 6 minutes.

TABLE 35 (Continued)

Round No.	Type of Sample	No. of Samples	Sampling Area	Access or Sampling Time	Concentration	Remarks
8	Observation		Fan Room 1-178-2-Q.			Smoke in area, entry through Door 1-179-2.
	Observation		Dry Provision Storeroom 6-207-0-A.			Smoke in area, entry through ventilation system.
9	Carbon Monoxide	1	Missile Checkout Area 1-174-0-M.	X to X+2.5 Min.	Less than 10 ppm	
		1	Missile Assembly and Loading Area 1-161-0-M.	X to X+2.5 Min.	Less than 10 ppm	
		1	Crew's Living Space 2-185-01-L.	X to X+2.5 Min.	Less than 10 ppm	
		1	Emergency Generator Control Room No. 2 2-203-2-Q.	X to X+2.5 Min.	Less than 10 ppm	
	*Lead	1	Missile Checkout Area 1-174-0-M.	X to X+5 Min.	.000 Mg/m^3	Wisp of smoke, dissipated rapidly.
		1	Crew's Living Space 2-185-01-L.	X to X+5 Min.	.000 Mg/m^3	
	**Lead	1	Emergency Generator Control Room No. 2 2-203-2-Q.	X to X+2.5 Min.	.054 Mg/m^3	
		1	Missile Checkout Area 1-174-0-M.	X to X+2.5 Min.	.000 Mg/m^3	
		1	Missile Assembly and Loading Area 1-161-0-M.	X to X+2.5 Min.	.000 Mg/m^3	
10	Carbon Monoxide	1	Missile Checkout Area 1-174-0-M.	X to X+2.5 Min.	Less than 10 ppm	
		1	Missile Assembly and Loading Area 1-161-0-M.	X to X+2.5 Min.	Less than 10 ppm	
		1	Passage 1-174-1-L.	X+5 Sec.	10 ppm	
	*Lead	1	Missile Checkout Area 1-174-0-M.	X to X+5 Min.	.000 Mg/m^3	
		1	Missile Assembly and Loading Area 1-161-0-M.	X to X+5 Min.	.000 Mg/m^3	
		1	Passage 1-174-1-L.			Electrical power failure.

TABLE 35 (Continued)

Round No.	Type of Sample	No. of Samples	Sampling Area	Access or Sampling Time	Concentration	Remarks
10	**Lead	1	Missile Checkout Area 1-174-0-M.	X to X+2.5 Min.	.000 Mg/m^3	
		1	Missile Assembly and Loading Area 1-161-0-M.	X to X+2.5 Min.	.000 Mg/m^3	
		1	Passage 1-174-1-L.			Smoke in area, persisted for approximately 5 minutes, entry through Door 1-176-1. Electrical power failure.

*Impinger method of collecting lead.
**Filter method of collecting lead.

Abbreviations: X close of firing circuit
ppm part per million
Mg/m^3 milligrams per cubic meter

TABLE 36 PRESSURE MEASUREMENTS

Rd. No.	Location	Peak Pressure (psig) Positive	Negative
7	Fuel Oil Vent (AE 6-161-2-F)	5.7	2.5
	Fuel Oil Vent (AE MN 6-174-0-F & 6-185-0-F)	5.7	0.5
	*Bulkhead, Frame 176, 18 inches above Main Deck	14.4	1.2
	*Bulkhead, Frame 176, 43 inches above Main Deck	16.0	1.0
	*Bulkhead, Frame 177, 36 inches above Main Deck	6.0	0.6
8	Fuel Oil Vent (AE 6-161-2-F)	0.4	2.9
	Fuel Oil Vent (AE MN 6-174-0-F & 6-185-0-F)	5.7	0.7
	*Bulkhead, Frame 176, 18 inches above Main Deck	16.0	1.0
	*Bulkhead, Frame 176, 43 inches above Main Deck	17.0	1.3
	*Bulkhead, Frame 177, 36 inches above Main Deck	5.5	0.4
10	Fuel Oil Vent (AE 6-161-1-F)	2.7	3.3
	Fuel Oil Vent (AE MN 6-174-0-F & 6-185-0-F)	4.7	2.4

*Gauge location shown in Figure 3.

TABLE 37 FLAME INDICATORS LOCATIONS

Locations	No. of Indicators Installed	Round
Port Blast Door (Forward)	32	1-6
Starboard Blast Door (Forward)	32	1-6
Port Strikedown Hatch (Forward)	36	1-6
Starboard Strikedown Hatch (Forward)	36	1-6
Observation Port (Forward)	8	1-6
Port Blast Door (Aft)	38	7-10
Starboard Blast Door (Aft)	39	7-10
Observation Port (Aft)	6	7-10
Door 1-176-1	24	7-10
Door 1-176-2	19	7-10
Door 1-180-3	19	7-10
Door 1-181-2	19	7-10
Door 1-181-4	19	7-10

APPENDIX B

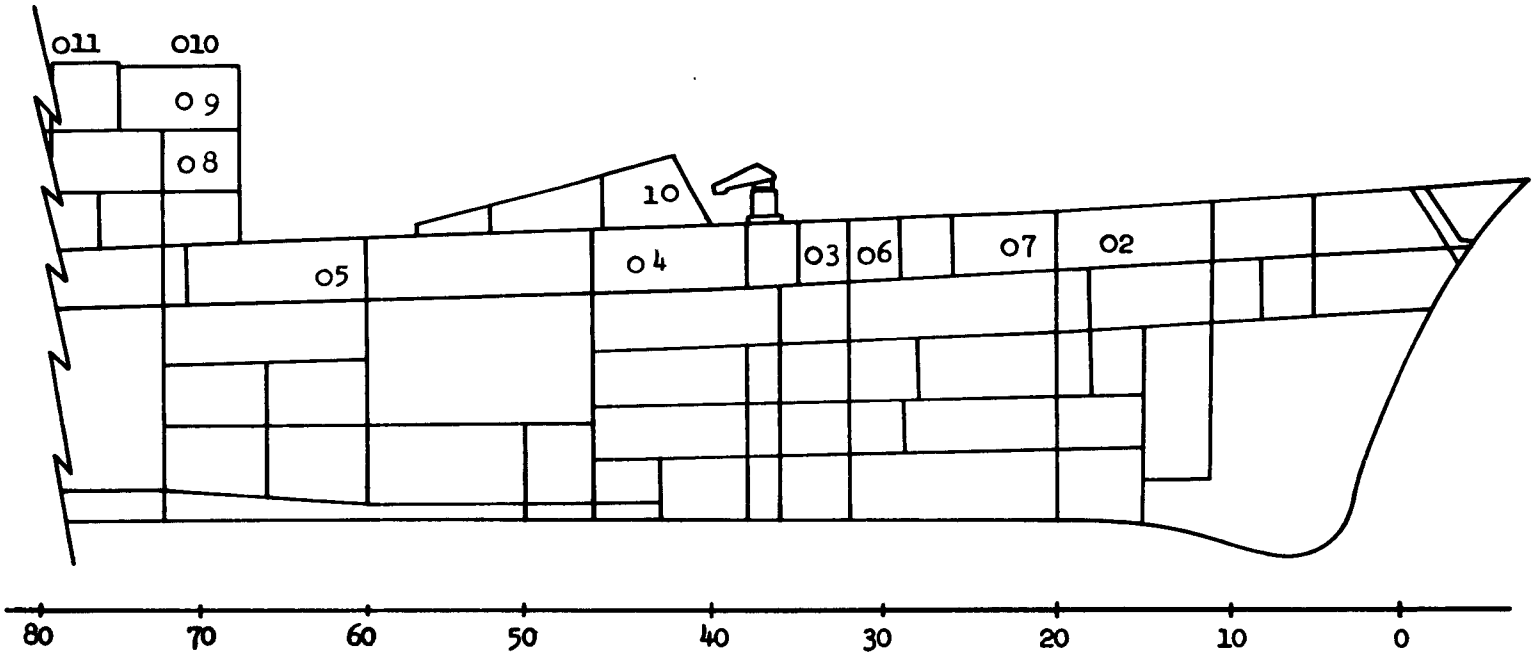
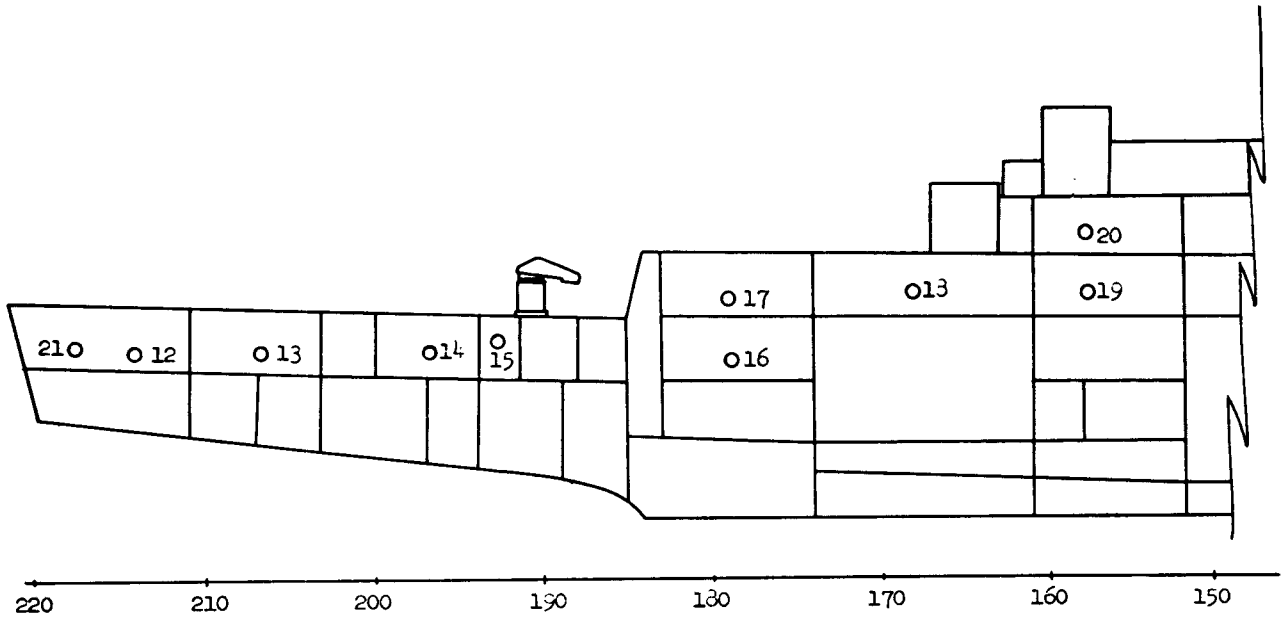
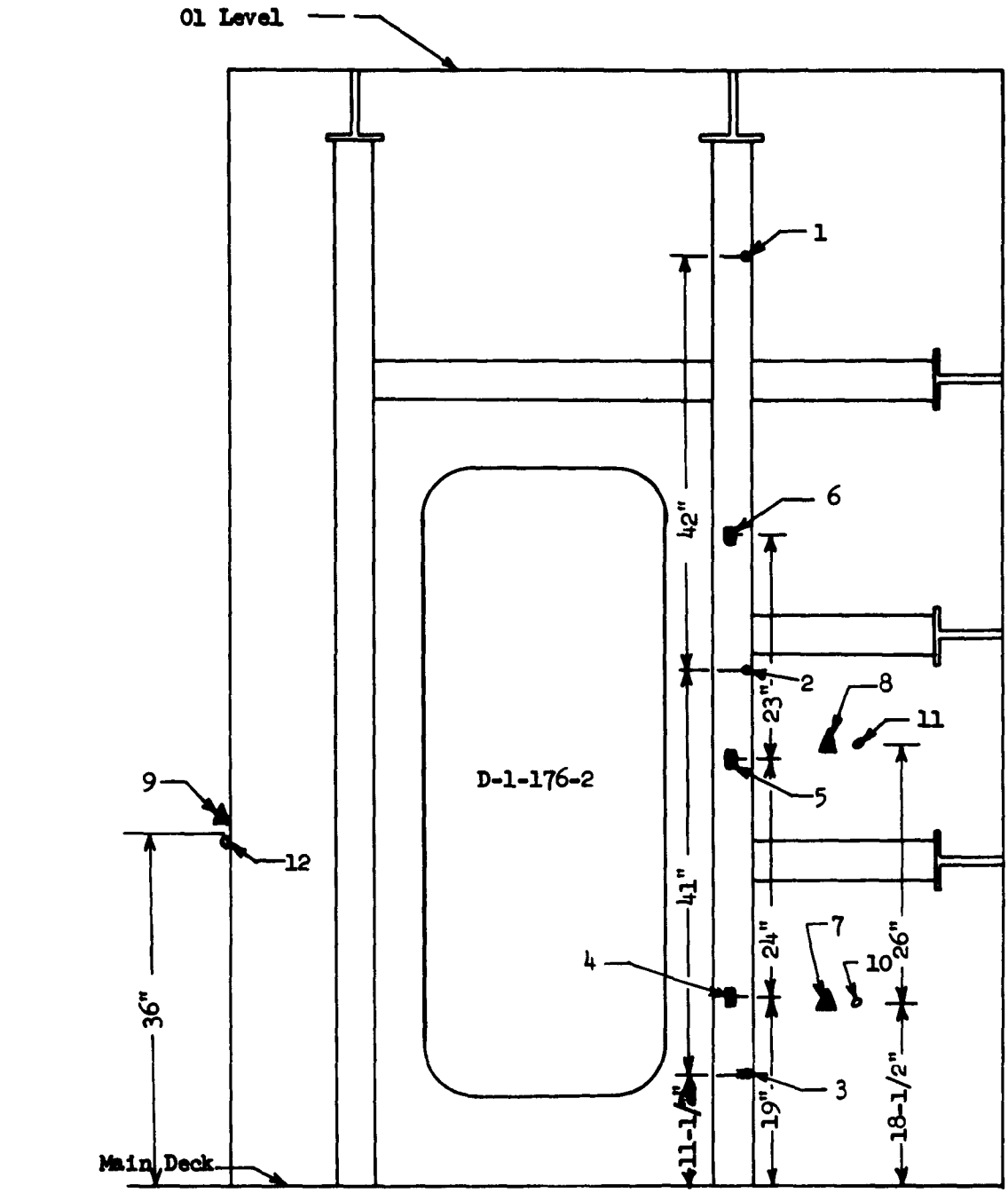

011
010
09
08
10
05
04
03
06
07
02
80
70
60
50
40
30
20
10
0
MICROPHONE LOCATIONS

Figure 1



MICROPHONE LOCATIONS

Figure 2



● Deflection Gauge

■ Strain Gauge

○ Pressure Gauge

▲ Temperature Gauge

Location of Transducers
Inside view looking aft.

Note: Gauges 9 and 12 are located on longitudinal bulkhead at Frame 177.

Figure 3

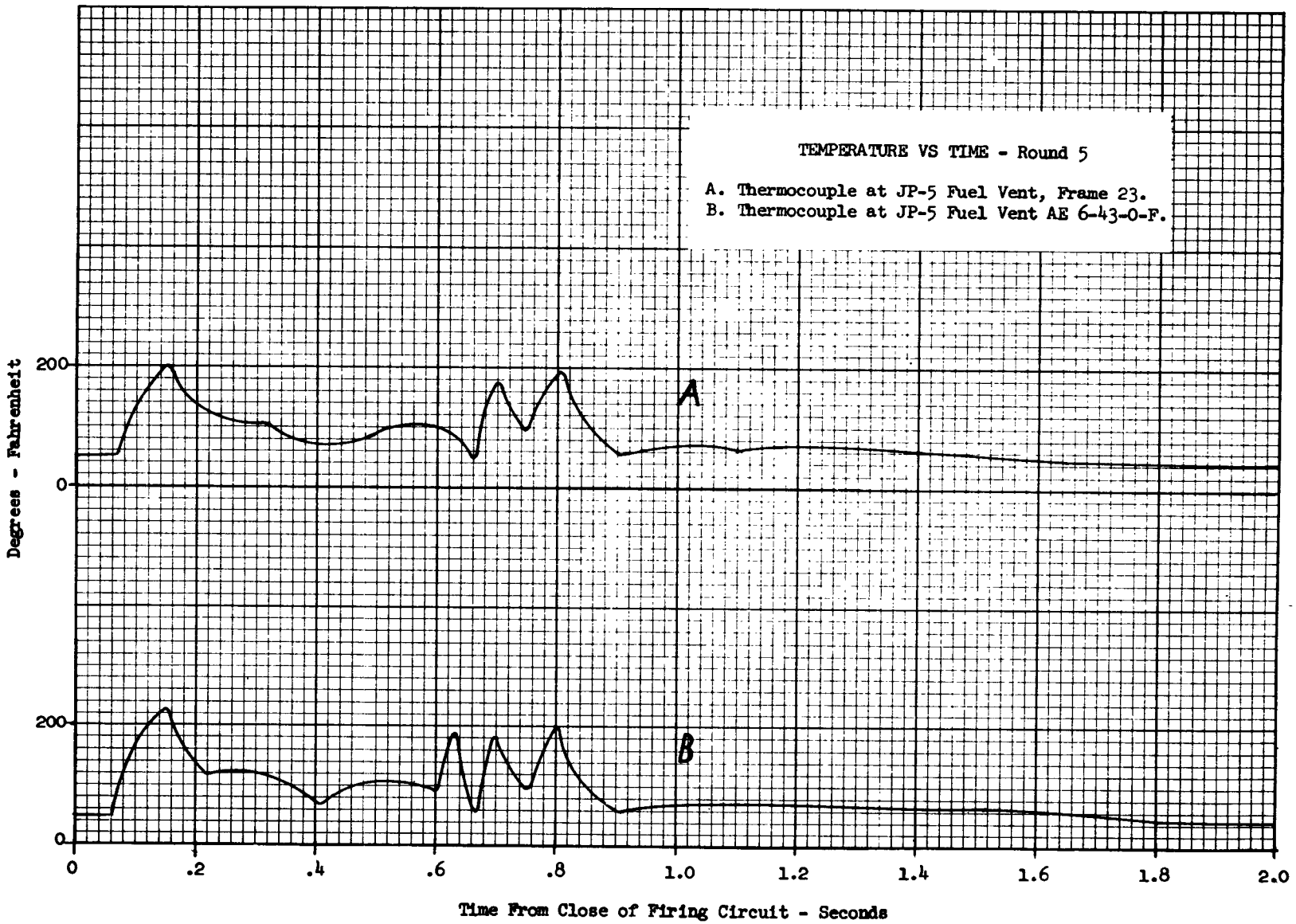

TEMPERATURE VS TIME - Round 5
A. Thermocouple at JP-5 Fuel Vent, Frame 23.
B. Thermocouple at JP-5 Fuel Vent AE 6-43-0-F.
Degrees - Fahrenheit
200
0
200
0
A
B
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
Time From Close of Firing Circuit - Seconds

Figure 4

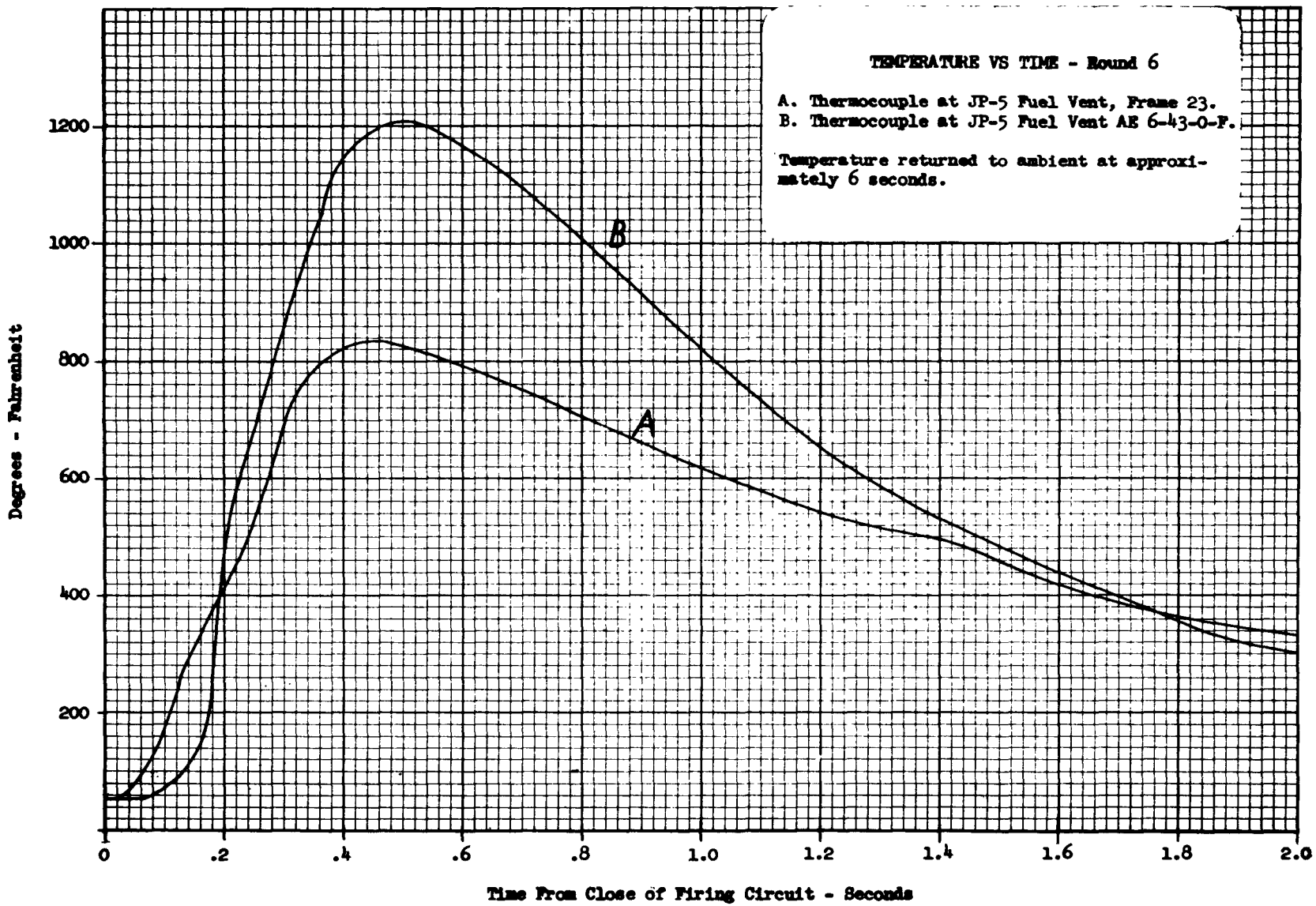

TEMPERATURE VS TIME - Round 6
A. Thermocouple at JP-5 Fuel Vent, Frame 23.
B. Thermocouple at JP-5 Fuel Vent AE 6-43-0-F.
Temperature returned to ambient at approximately 6 seconds.
B
A
1200
1000
800
600
400
200
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
Degrees - Fahrenheit
Time From Close of Firing Circuit - Seconds

Figure 5

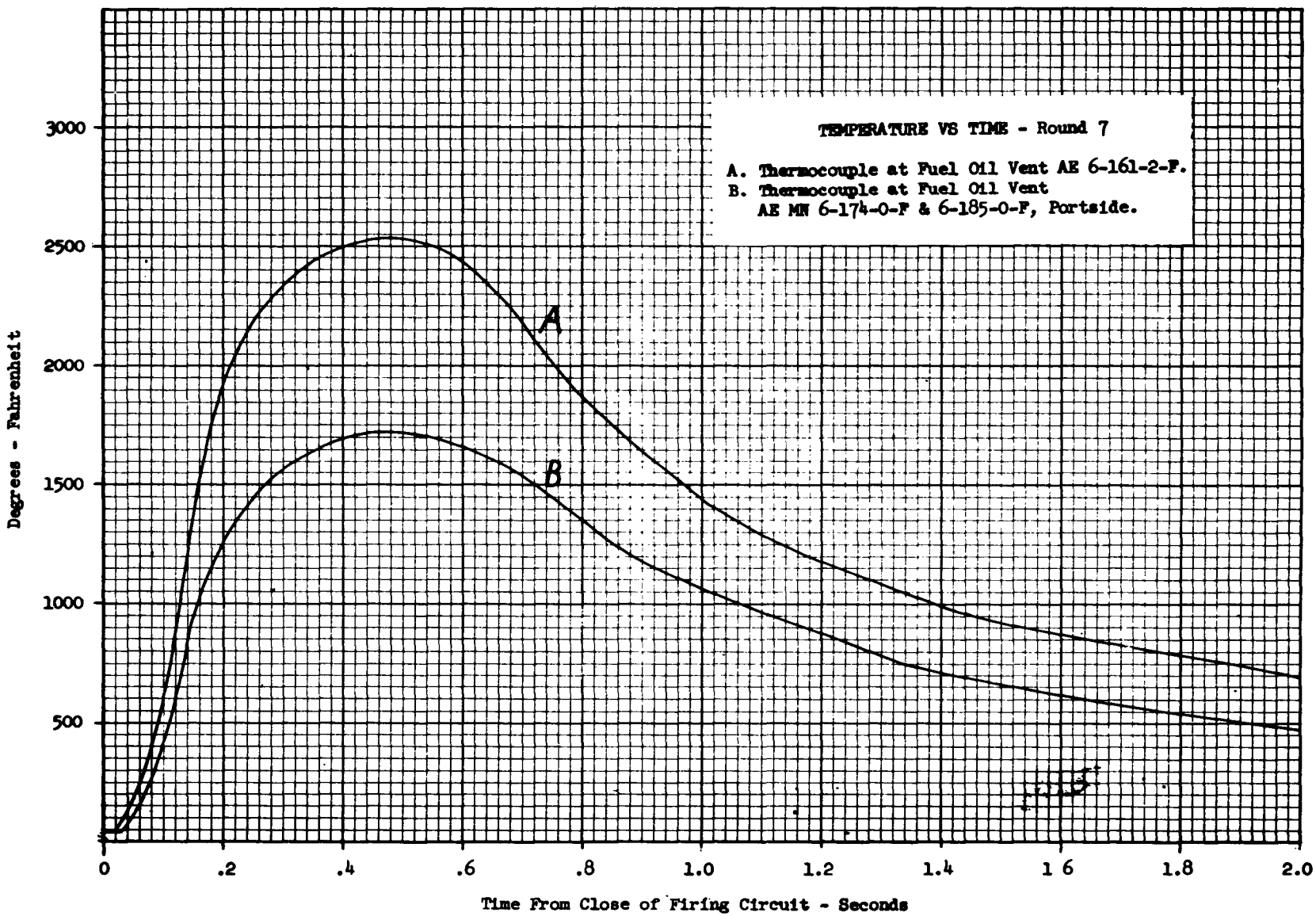

TEMPERATURE VS TIME - Round 7
A. Thermocouple at Fuel Oil Vent AE 6-161-2-F.
B. Thermocouple at Fuel Oil Vent
AE MN 6-174-0-F & 6-185-0-F, Portside.
A
B
3000
2500
2000
1500
1000
500
Degrees - Fahrenheit
0
.2
.4
.6
.8
1.0
1.2
1.4
1 6
1.8
2.0
Time From Close of Firing Circuit - Seconds

Figure 6

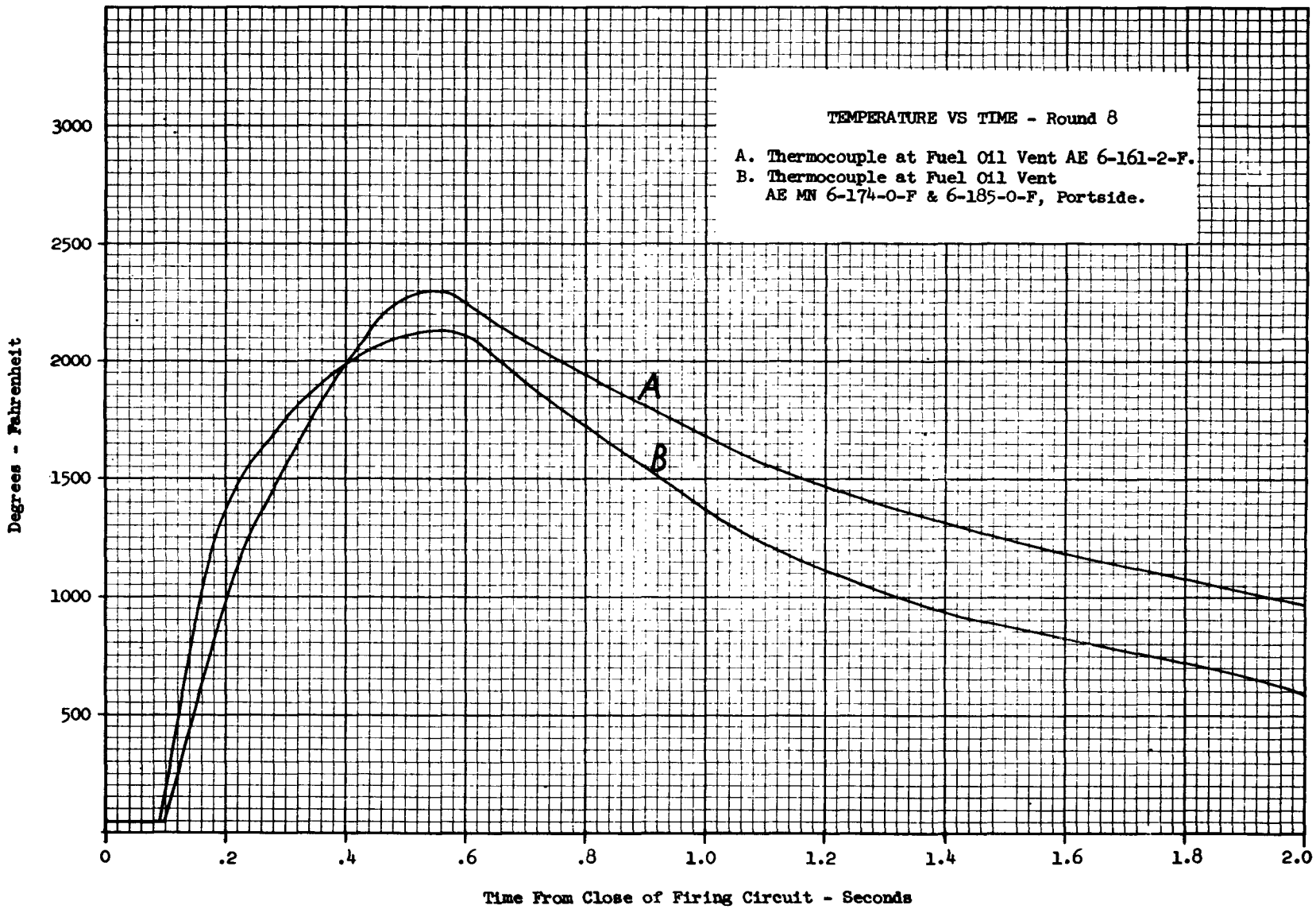

TEMPERATURE VS TIME - Round 8
A. Thermocouple at Fuel Oil Vent AE 6-161-2-F.
B. Thermocouple at Fuel Oil Vent
AE MN 6-174-0-F & 6-185-0-F, Portside.
Degrees - Fahrenheit
3000
2500
2000
1500
1000
500
A
B
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
Time From Close of Firing Circuit - Seconds

Figure 7

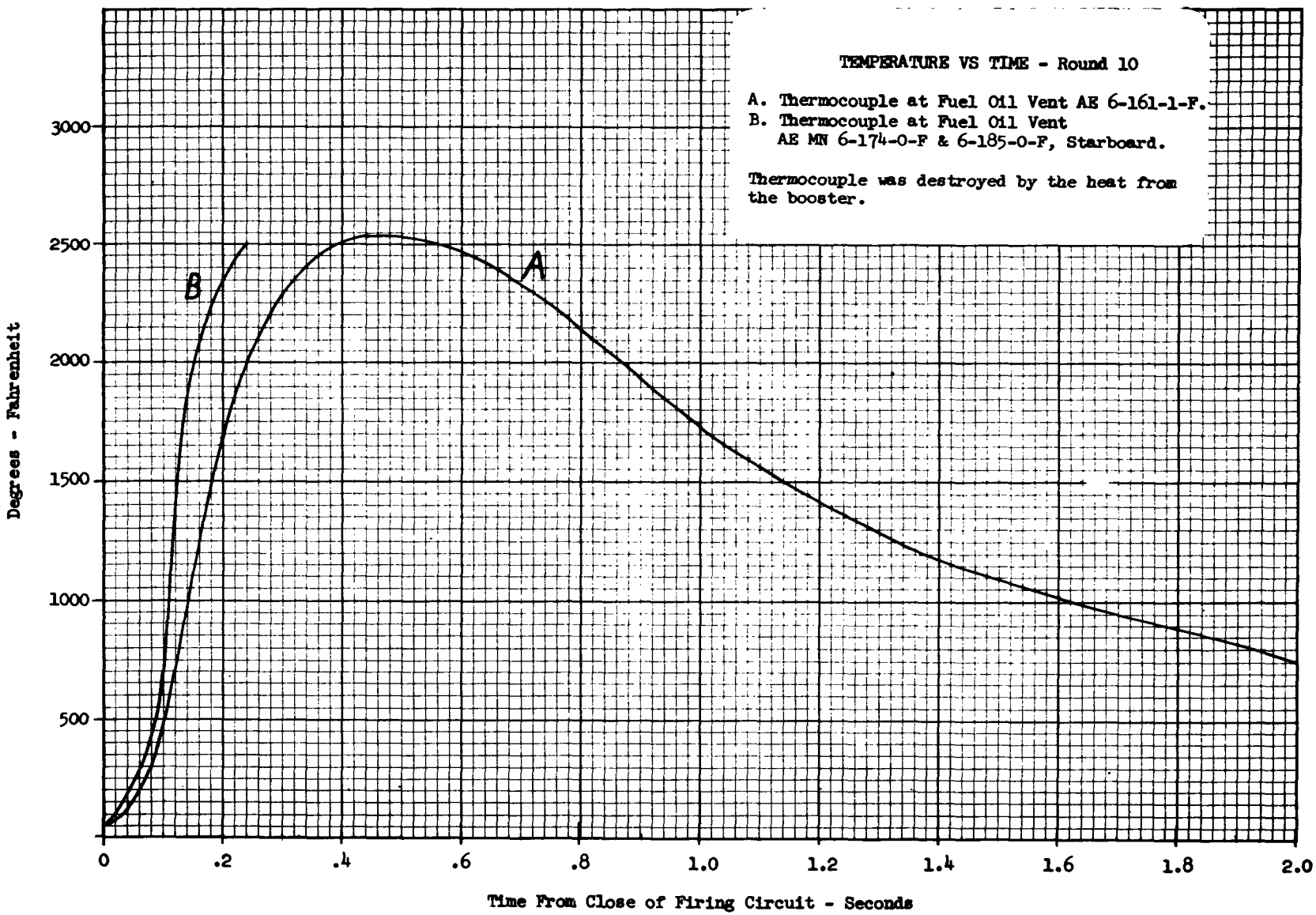
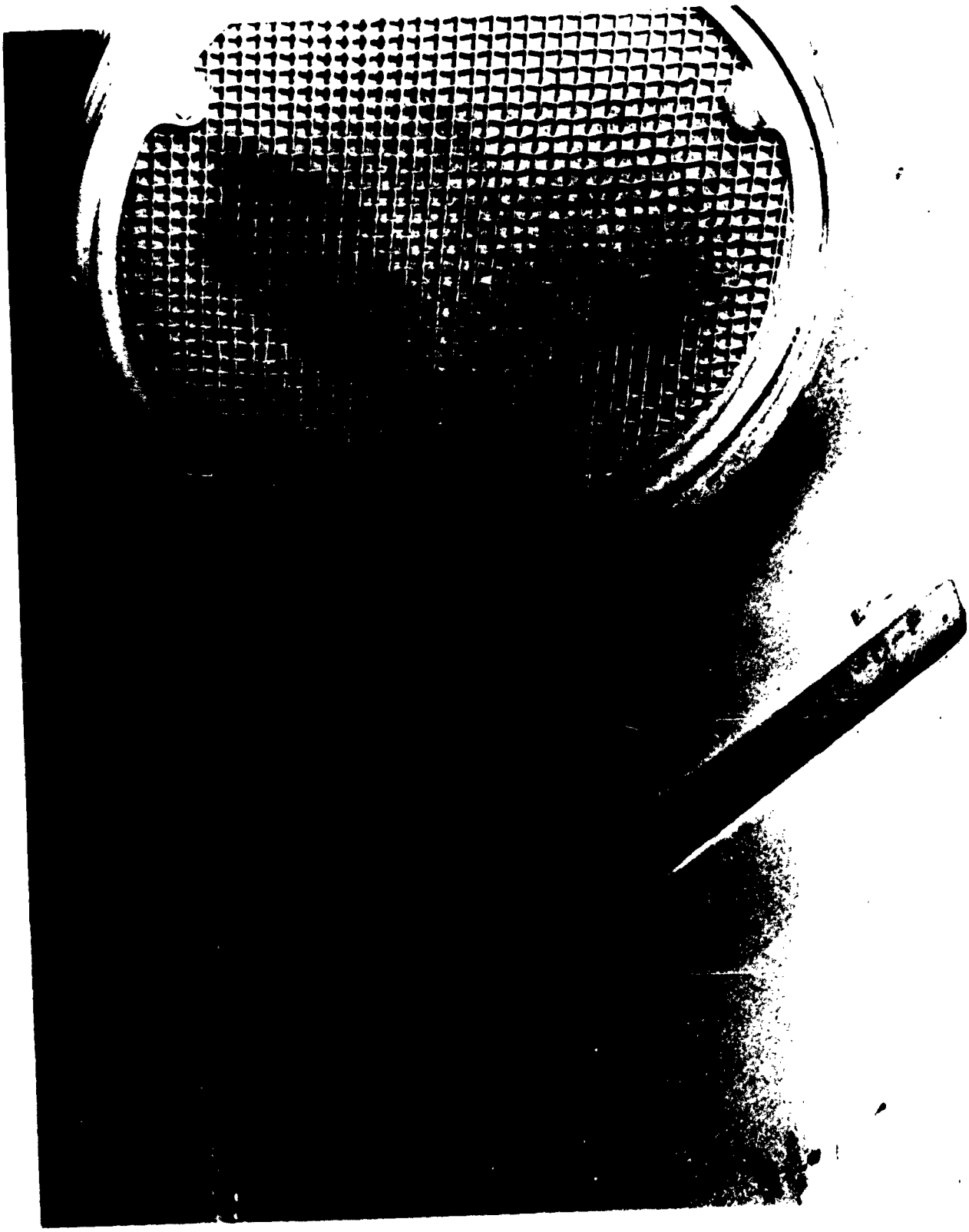

TEMPERATURE VS TIME - Round 10
A. Thermocouple at Fuel Oil Vent AE 6-161-1-F.
B. Thermocouple at Fuel Oil Vent
AE MN 6-174-0-F & 6-185-0-F, Starboard.
Thermocouple was destroyed by the heat from the booster.
A
B
Degrees - Fahrenheit
3000
2500
2000
1500
1000
500
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
Time From Close of Firing Circuit - Seconds

Figure 8



PHD-90047-10-62 Figure 9 26 October 1962

Fuel Oil Air Escape Vent After Round 7

A. Pressure probe.
B. Temperature probe.

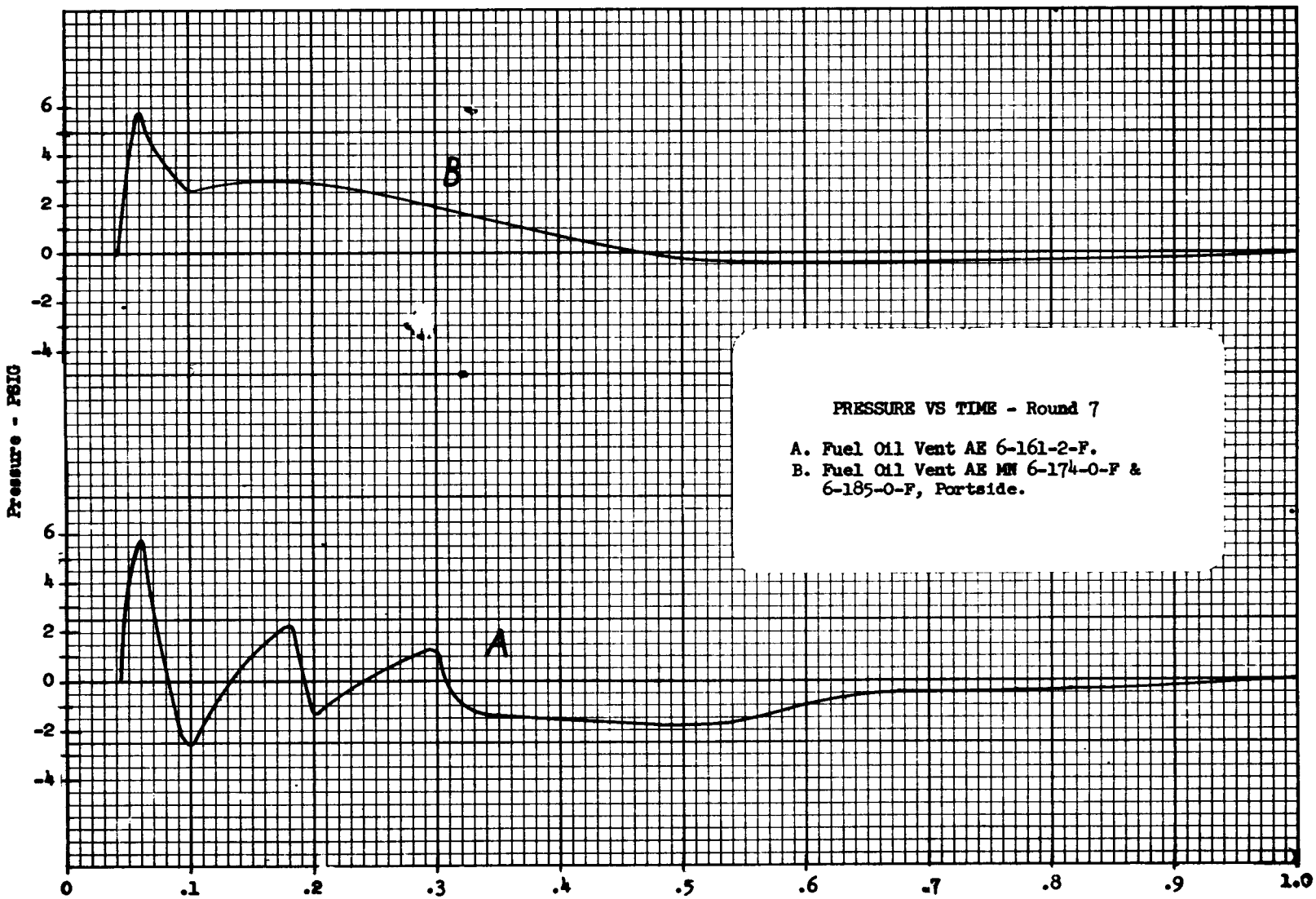

PRESSURE VS TIME - Round 7
A. Fuel Oil Vent AE 6-161-2-F.
B. Fuel Oil Vent AE MN 6-174-0-F & 6-185-0-F, Portside.
Pressure - PSIG
Time From Close of Firing Circuit - Seconds
B
A
6
4
2
0
-2
-4
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

Figure 10

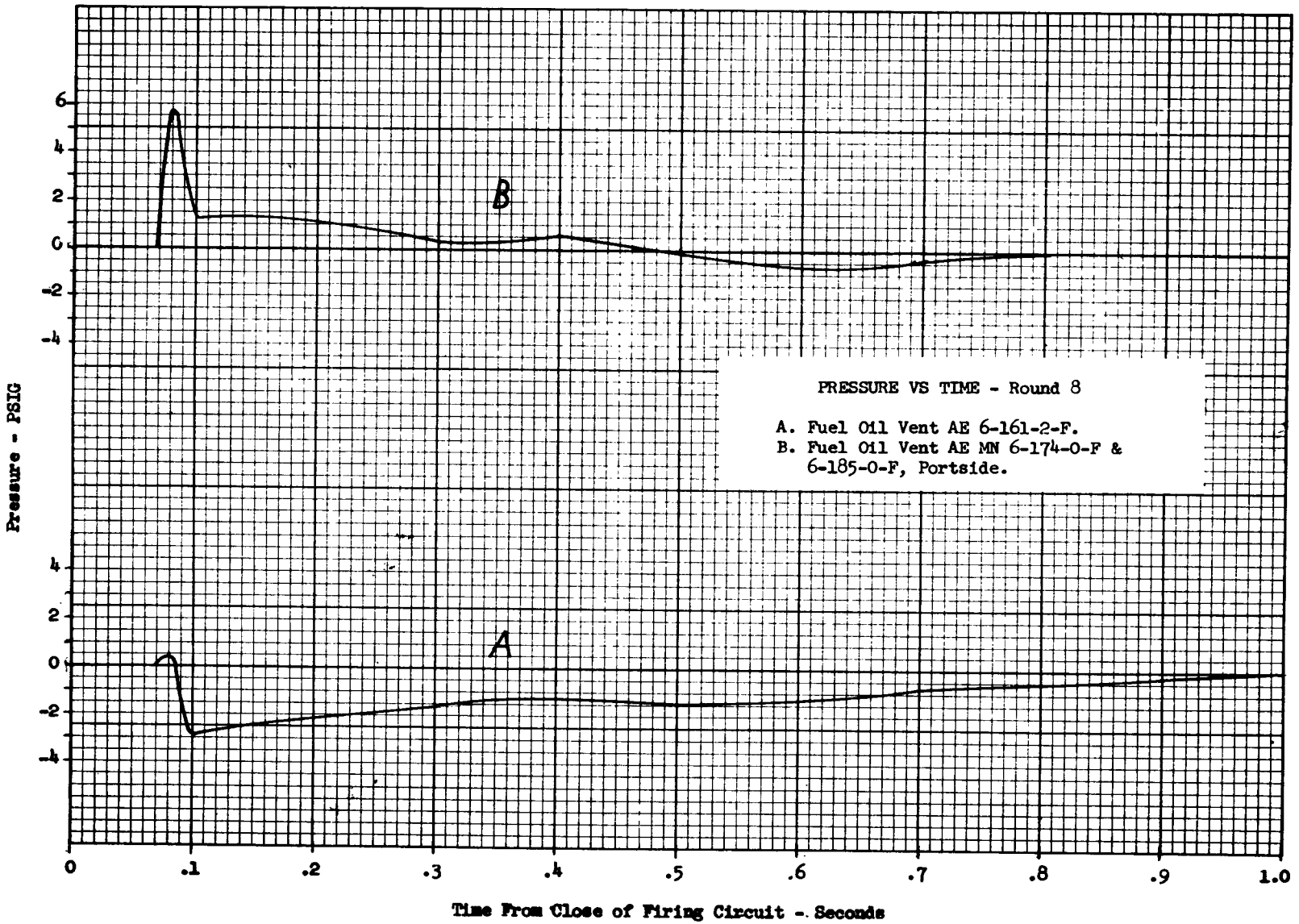

PRESSURE VS TIME - Round 8
A. Fuel Oil Vent AE 6-161-2-F.
B. Fuel Oil Vent AE MN 6-174-0-F & 6-185-0-F, Portside.
B
A
Pressure - PSIG
6
4
2
0
-2
-4
4
2
0
-2
-4
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
Time From Close of Firing Circuit - Seconds

Figure 11

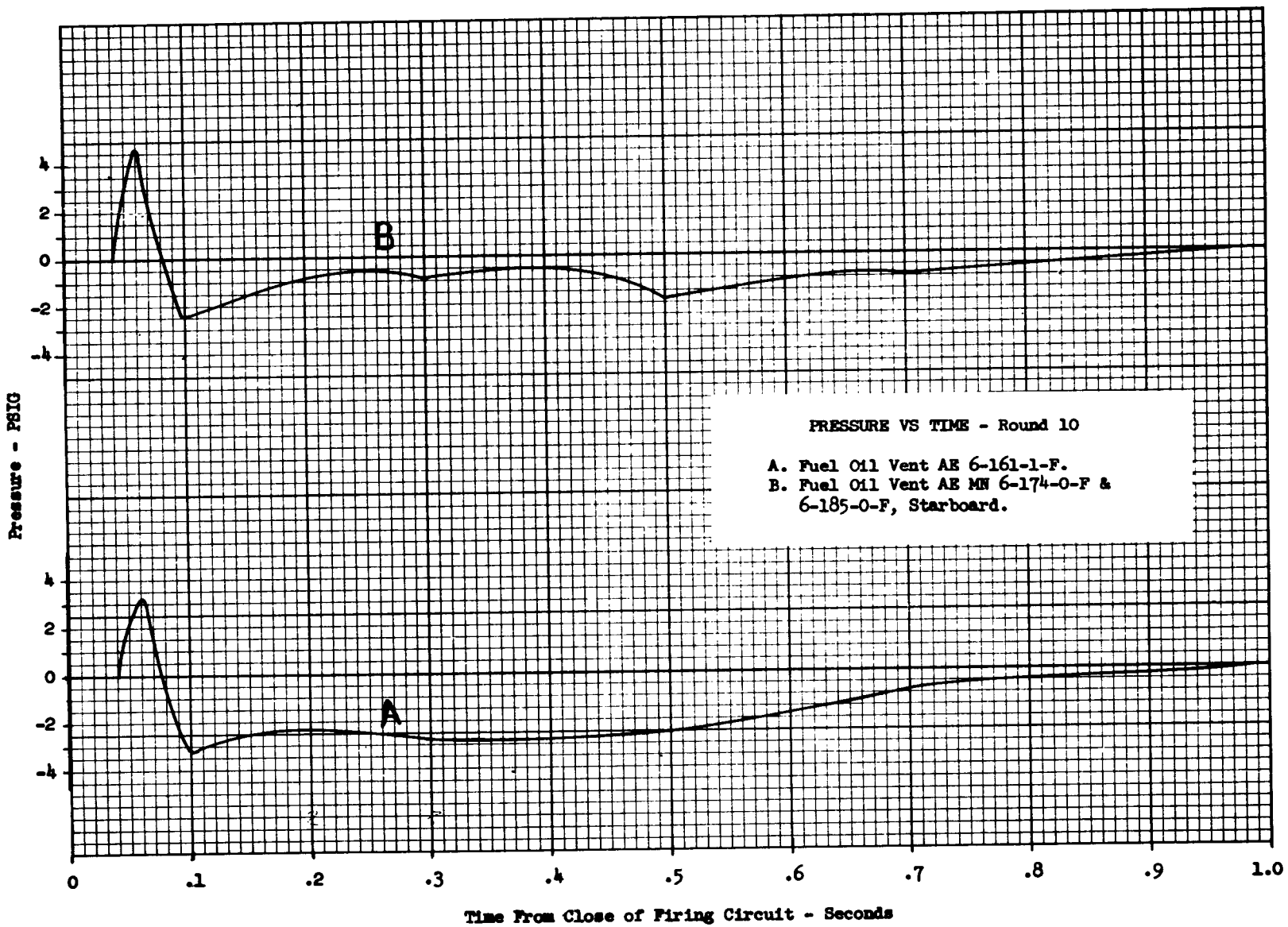

PRESSURE VS TIME - Round 10
A. Fuel Oil Vent AE 6-161-1-F.
B. Fuel Oil Vent AE MN 6-174-0-F & 6-185-0-F, Starboard.
B
A
Pressure - PSIG
4
2
0
-2
-4
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
Time From Close of Firing Circuit - Seconds

Figure 12

PHD-90049-10-62 Figure 13 25 October 1962

Observer's Port in forward Missile House

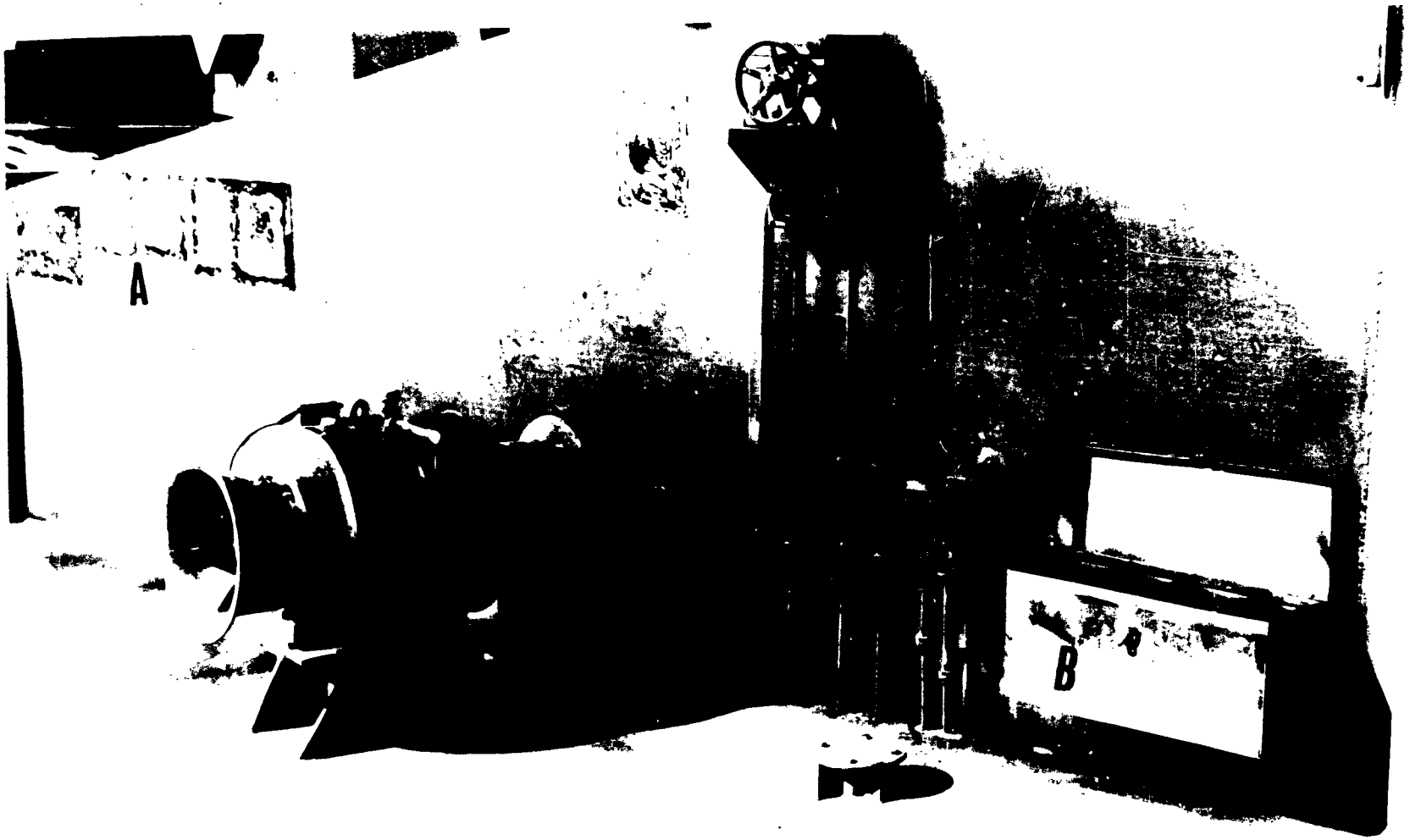


Figure 14
Starboard Side of Forward Missile House
A. Location of missing instruction plates.
B. Damaged sound powered phone storage box.

A Dud Jettisoning Unit, Launcher No. 1
A. Modification to unit.

PHD-90043-10-62 Figure 17 26 October 1962

Ball Check Valves for Fuel Oil Vents at completion of tests.

A. Vent (AE 6-161-2-F).
B. Vent (AE MN 6-174-C-F & 6-185-O-F) Portside.
C. Vent (AE MN 6-174-O-F & 6-185-C-F) Starboard side.
D. Vent (AE 6-161-1-F).
E. Rupture in vent D.

The circle at the top of check valves B, C and D is where the balls were distorted. Note the severe damage to the flame screens.

PHD-90054-10-62 Figure 18 25 October 1962

Starboard Side of Main Deck, Frame 176

A. Door 1-176-1 unlatched during Round 10.
B. Hose rack.
C. Identification tag blown away by the booster blast.

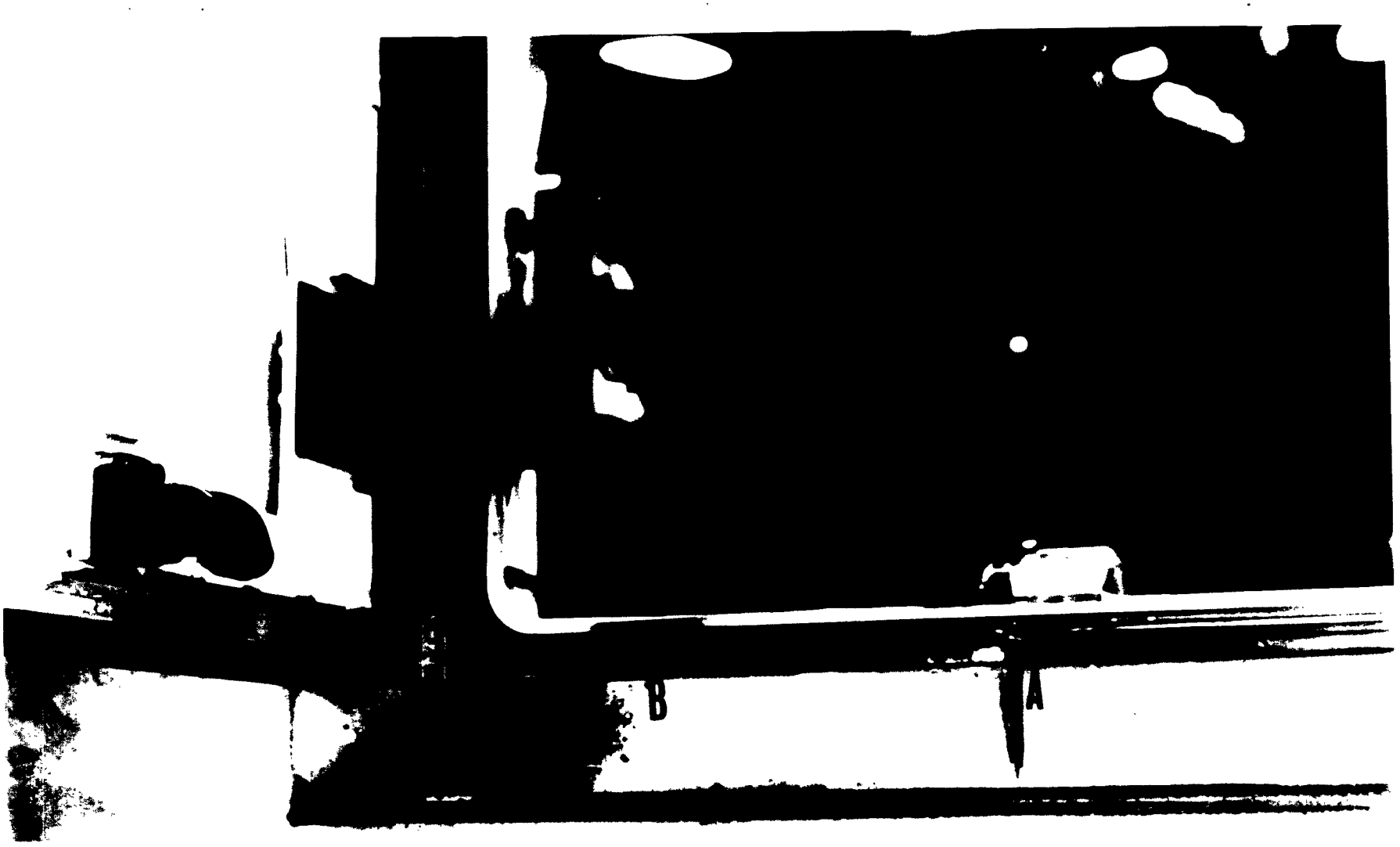


Figure 19
A Blast Door

A. Spring clips blown loose from gasket.
B. Area where smoke leakage occurred.

PHD-90046-10-62 Figure 20 26 October 1962

Portside of Main Deck, Frame 176

A. Fan Room 1-178-2-Q.
B. Pin blown loose during Round 7 permitting ladder to be twisted.
C. Damage sound powered phone storage box.
D. Securing clamp for boat boom king post bent upward permitting post to come loose.
E. Broken life line.

APPENDIX C

DETAILS OF TEST EQUIPMENT AND PROCEDURES

1. Deflection Measurements

The deflection gauge consists of a flat steel cantilever bar secured to a fixed supporting structure in such a manner that the deflection of the structure under test stresses the cantilever. A Baldwin-Lima-Hamilton Corporation SR-4 500 ohm Type A-14 Strain Gauge is cemented to the cantilever and a known deflection is applied in order to obtain the relation between stress in the bar and the magnitude of deflection. Each gauge forms an active arm of a Wheatstone Bridge circuit which is connected to one channel of a galvanometer oscillograph. Figure 3 indicates the location of the deflection gauges.

2. Strain Measurements

Resistance strain gauges were used to obtain the strain measurements. The strain gauges were bonded to the vertical stiffener along the portside of Door D-1-176-2. Figure 3 indicates the location of the strain gauges. The outputs from the strain gauges were recorded on a galvanometer oscillograph.

3. Sound Pressure Levels

Calibrated condenser microphones were used to measure the sound pressure levels. The outputs from these microphones were recorded on magnetic tape and later analysed with an audio-frequency spectrometer.

All the microphones were shock mounted with the diaphragm positioned in a horizontal plane. Before each test, the microphone systems were calibrated by applying a pure 400 cycle tone at 121 db with respect to the reference level 0.0002 dynes/cm^2.

4. Toxic Gas Sampling

Air samples were collected at the completion of each test with various gas sampling equipment to determine the presence and concentration of toxic substances. Before each test, air

samples were collected to determine if lead or carbon monoxide was present from the previous test. The types of gas samplers used were:

Gas	Sampler
Carbon Monoxide	Aminco[1] peristaltic pumps with Mine Safety Appliance (M-S-A) carbon monoxide indicating tubes.
	M-S-A Tester, Type By-47133.
Lead	M-S-A Lead in Air Detector.
	High velocity air samplers with Whatman No. 41 filter paper.
	Greenburg-Smith Impingers containing 1.99 Nitric Acid (HNO_3) aspirated by a Gast vacuum pump.

[1]American Instrument Company.

5. Temperature Measurements

Iron-constantan thermocouples fabricated from No. 30 thermocouple wires were used to monitor the temperature at the locations indicated in Table 4. The outputs from the thermocouples were recorded on a galvanometer oscillograph.

6. Pressure Measurements

Unbonded strain gauges were used to measure pressure. The outputs from the transducers were recorded on a galvanometer oscillograph with a system sensitivity capable of detecting pressures as low as four ounces per square inch.

7. Flame Indicators

The flame indicators used were two-inch squares of wine colored rayon-acetate taffeta. This material has an ignition energy of two calories per square centimeter according to the government publication, "The Effects of Nuclear Weapons" dated June 1957.

The flame indicators were installed around the periphery of ports, doors and hatches as indicated by Table 37. After each firing, the areas tested were examined and a record made of any cloth tuffs which had been displaced, melted or burned.

APPENDIX D

DETAILED TEST CONDITIONS AND OBJECTIVES

LAUNCHER NO. 1

Test No. 1

Condition: A rail loaded. Train 328° Elevation 26°.

Impingement Point Location: Observer's Port.

Objectives:

1. To determine the effect of direct booster blast on the observer's port and the B blast door.

2. To determine the effect of booster blast on the FAST Automatic Shuttle Transfer (FAST) equipment located on top of the missile house.

3. To test for safe habitability of the missile house during missile firings.

Test No. 2

Condition: A rail loaded. Train 030° Elevation 36°.

Impingement Point Location: Port Missile Strikedown Hatch.

Objectives:

1. To test for adequacy of structural strength and gas and flame tightness of the port missile strikedown hatch under conditions of direct booster blast.

2. To determine the effect of booster blast on equipment located on the portside of the missile house.

3. To determine the effect of booster blast spillover on the ASROC launcher.

4. To test for safe habitability of the missile house and main deck areas during missile firings.

Test No. 3

Condition: B rail loaded. Train 342°02' Elevation 27°.

Impingement Point Location: Starboard Missile Strikedown Hatch.

Objectives:

1. To test for adequacy of structural strength and gas and flame tightness of the starboard missile strikedown hatch under conditions of direct booster blast.

2. To determine the effect of booster blast on equipment located on the starboard side of the missile house.

3. To determine the effect of booster blast spillover on the ASROC launcher.

4. To test for safe habitability of the missile house and main deck areas during missile firings.

Test No. 4

Condition: A rail loaded. Train 308° Elevation 02°17'.

Impingement Point Location: Upper Starboard Edge of Missile House Face Plate.

Objectives:

1. To determine the effect of booster blast spillover on FAST equipment located on top of the missile house.

2. To determine the effect of booster blast on the B blast door.

3. To test for safe habitability of the missile house during missile firings.

Test No. 5

Condition: A rail loaded. Train 147°05' Elevation 14°06'.

Impingement Point Location: Scuttle S-01-25-2.

Objectives:

1. To test for adequacy of structural strength and gas and flame tightness of Scuttle S-01-25-2 and air intake and exhaust vents located on the main deck portside between Frames 22 and 26.

2. To determine the effect of booster blast on JP-5 air escape vents located at Frames 19 and 23.

3. To test for safe habitability of the main deck areas during missile firings.

Test No. 6

Condition: A rail loaded. Train 176° Elevation 40°28'.

Impingement Point Location: A Dud Jettisoning Unit.

Objectives:

1. To determine the effect of direct booster blast on the A dud jettisoning unit.

2. To test for adequacy of structural strength and gas and flame tightness of the air vents located forward of the dud jettisoning unit.

3. To test for safe habitability of the main deck areas during missile firings.

LAUNCHER NO. 2

Test No. 1

Condition: B rail loaded. Train 147°08' Elevation 11°.

Impingement Point Location: Main Deck, Portside, Frame 178.

Objectives:

1. To test for adequacy of structural strength of the air exhaust vent located at Frame 178.

2. To determine the effect of booster blast on the fuel oil air escape vents located at Frame 176 portside.

3. To determine the effect of booster blast spillover on equipment located on the vertical bulkhead and around the edge of the 01 level.

4. To test for safe habitability of the deck house during missile firings.

Test No. 2

Condition: B rail loaded. Train 149°26' Elevation 11°.

Impingement Point Location: Slanting Bulkhead Portside Frame 182-1/2.

Objectives:

1. To determine the effect of booster blast spillover on air exhaust vent at Frame 178.

2. To determine the effect of booster blast spillover on fuel oil air escape vents at Frame 176 portside.

3. To determine the effect of booster blast spillover on equipment located on the vertical bulkhead and around the edge of the 01 level.

4. To test for safe habitability of the deck house during missile firings.

Test No. 3

Condition: A rail loaded. Train 165°25' Elevation 11°.

Impingement Point Location: Observer's Port.

Objectives:

1. To determine the effect of direct booster blast on the A blast door and its seals and the observer's port.

2. To determine the effect of booster blast spillover on the 01 level.

3. To test for safe habitability of the missile house during missile firings.

Test No. 4

Condition: A rail loaded. Train 212°25' Elevation 11°.

Impingement Point Location: Main Deck, Starboard Side, Frame 178.

Objectives:

1. To determine the effect of booster blast on the fuel oil air escape vents located at Frame 176 starboard side.

2. To determine the effect of booster blast spillover on equipment located on the vertical bulkhead and around the edge of the 01 level starboard side.

3. To test for safe habitability of the deck house during missile firings.

APPENDIX E

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BIBLIOGRAPHIC INFORMATION

DESCRIPTOR	CODE	DESCRIPTOR	CODE
SOURCE Naval Weapons Laboratory	NPGA	SECURITY CLASSIFICATION AND CODE COUNT UNCLASSIFIED	U031
REPORT NUMBER 1857	1857	CIRCULATION LIMITATION	
REPORT DATE May 1963	0563	CIRCULATION LIMITATION OR BIBLIOGRAPHIC	
		BIBLIOGRAPHIC *(Suppl., Vol., etc.)*	

SUBJECT ANALYSIS OF REPORT

DESCRIPTOR	CODE	DESCRIPTOR	CODE	DESCRIPTOR	CODE
Terrier (Missile)	TERR	Boosters	BOOS	Damage	DAMA
Structural	STRC	Blast	BLAS	Mark 12 Mod 0	MARK
Firing	FIRI	Effects	EFFE		12MO
Tests	TEST	Ships	SHIP		
Leahy (USS)	LEAH	Equipment	EQUI		
(Frigate, guided DLG missile)	DLGA	Vehicles	VEHC		
16	0016	Deflection	DEFL		
Guided	GUIE	Temperatures	TEMP		
Missiles	MISL	Pressure	PRES		
Ship-to-air	SHIO	Measurements	MEAU		
Launching	LAUC	Launchers	LAUN		
Systems	SYST	Toxicity	TOXI		
Personnel	PERS	Gases	GASE		
Safety	SAFE	Leakage	LEAK		

Naval Weapons Laboratory, Dahlgren, Virginia. (NWL Report No. 1857) TERRIER STRUCTURAL FIRING TEST ABOARD THE USS LEAHY (DLG-16), by J. W. Loving and others. 9 May 1963. 17 p., 20 figs., 37 tables. UNCLASSIFIED 10 TERRIER Mk 12 Mod 0 boosters with concrete slugs were fired aboard the USS LEAHY to investigate the adequacy of protection for the TERRIER launching system personnel against blast effects and to determine the effects of the booster blast on the ship's structure. Tests indicated leakage of gas and smoke into the ship through ventilation systems and past seals of various doors and ports, high temperature changes at the openings of the air escape vents for the JP-5 and the fuel oil tanks; and minor structural damage to equipment in the launcher areas.	1. Guided missile boosters - Mk 12 2. Guided missile launchers 3. Personnel - Safety measures 4. Ships - Structural analysis 5. Ships - Blast effects I. TERRIER II. USS LEAHY III. Loving, J. W. IV. Dodson, T. I. V. Wine, P. E. VI. Lamonica, J. A. Task: RM2548-004/210-3/ W015B-006 UNCLASSIFIED	Naval Weapons Laboratory, Dahlgren, Virginia. (NWL Report No. 1857) TERRIER STRUCTURAL FIRING TEST ABOARD THE USS LEAHY (DLG-16), by J. W. Loving and others. 9 May 1963. 17 p., 20 figs., 37 tables. UNCLASSIFIED 10 TERRIER Mk 12 Mod 0 boosters with concrete slugs were fired aboard the USS LEAHY to investigate the adequacy of protection for the TERRIER launching system personnel against blast effects and to determine the effects of the booster blast on the ship's structure. Tests indicated leakage of gas and smoke into the ship through ventilation systems and past seals of various doors and ports, high temperature changes at the openings of the air escape vents for the JP-5 and the fuel oil tanks; and minor structural damage to equipment in the launcher areas.	1. Guided missile boosters - Mk 12 2. Guided missile launchers 3. Personnel - Safety measures 4. Ships - Structural analysis 5. Ships - Blast effects I. TERRIER II. USS LEAHY III. Loving, J. W. IV. Dodson, T. I. V. Wine, P. E. VI. Lamonica, J. A. Task: RM2548-004/210-3/ W015B-006 UNCLASSIFIED
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